Investigation of Finger-Reading Effect and Tactile Relief Recognition

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To my parents

The most beautiful thing we can experience is the mysterious. It is the source of all true art and science. (Albert Einstein)

Acknowledgements & Declaration

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Declaration

I have composed this thesis, and the work is my own.

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Abstract

This thesis considers the claim that people, with appropriate training, can discriminate between different printed materials even when they do not look at them, by using their finger-tips instead of their eyes to perceive what is on the paper. This is known as 'finger-reading ability'. The finger-reading training process was originally developed by Si-Chen Lee and previous research appears to indicate that such training yields increased (exceptional) tactile recognition or extrasensory perception in the fingertips of children. This is apparently indicative of some new means of communication beyond those presently understood. However, this effect might have involved fraud. It is thus not safe to assume that this ability was successfully measured in previous studies. This thesis presents the development of a well-controlled finger-reading training paradigm and three experiments aimed at investigating the finger-reading effect.

Four stages were proposed to develop a well-controlled paradigm of finger-reading training using more stringent controls. The first step was to review the studies of the finger-reading effect with a view to identifying the proposed questions and designing effective methods suitable for use in subsequent studies. Secondly, the author discussed fraud, safeguards and factors affecting ESP performance. Thirdly, pilot trials were considered which would develop techniques empirically and assess controls on the finger-reading training processes. Finally, a well-developed finger-reading training paradigm was established.

The first experiment conducted for this thesis was designed to determine the limits of tactile relief recognition. It is about to what extent are people able to recognise printed characters through the medium of touch. The study, in particular, examined the extent to which characters on a sheet of paper must be elevated above the plane of the paper in order for them to be recognisable by touch. Six elevations (0.05 mm, 0.1 mm, 0.2 mm, 0.3 mm, 0.4 mm, 0.5 mm) of nine digits (1, 2, 3, 4, 5, 6, 7, 8, 0) recognition tasks were presented to 24 children and 24 adults. The performance of recognising nine digits with all six elevations was significantly lower in the child group compared to the adult group. Poorer tactile relief acuity in children may represent an immature tactile mechanism. A threshold between 0.05 mm and zero for 1, 7 and 0 could be observed in the children, whilst the other digits are the 2 and 3 at 0.19 mm, 8 at 0.17 mm, 4, 5 and 6 at >0.5 mm. It is expected that children would fail to recognise digits with elevations between 0.05 mm and zero, except 1, 7 and 0. Since the evidence suggests that, for at least some of the digits, children have a

tactile acuity for differentiating among materials between 0.05 mm and zero, it was decided to use targets with zero elevation in the subsequent finger-reading experiments with a view to entirely ruling out possible tactile cues for raised characters.

In the second experiment, eighteen children aged 7 to 12 were tested individually and asked to determine the identity of a target by means of directly touching a flat two-digit number varying between four different colours on paper, using a newly developed finger-reading training paradigm. Questionnaires measured participants' mental imagery, paranormal beliefs and tactual experience. It was predicted that a quarter of the child participants, after finger-reading training for eight hours, would demonstrate finger-reading ability. Overall, no significant results were found. There were no significant relationships between scoring and mental imagery, paranormal beliefs or tactual experience.

The third experiment included three phases: a selection study, a confirmation study and a training study, in the hope of selecting possibly talented participants. 2,200 child participants aged from six to thirteen had been invited and 1,771 joined in this experiment. 1,655 completed ten trials in the selection study. 820 participants among 1655 participants scored one hit or more hits, of recognition of a two-digit number with a colour. All 820 were invited to the confirmation study. 728 joined in the confirmation study and they all completed twenty trials. None of them scored above one hit of recognition of numbers with colours. This study failed in its objective of selecting potential children to acquire finger-reading ability.

Overall, though the findings of the experiments did not offer support to the existence of finger-reading ability, this does not necessarily mean that the finger-reading does not exist. More research is needed. This thesis offers a proposed ESP training model and a modified finger-reading training paradigm under stringent conditions for future studies to investigate the finger-reading effect.

Chapter 1. Introduction to Psi and finger reading[1]

1.1 Introduction

The Way

The Way that can be experienced is not true;
The world that can be constructed is not true.
The Way manifests all that happens and may happen;
The world represents all that exists and may exist.

To experience without intention is to sense the world;
To experience with intention is to anticipate the world.
These two experiences are indistinguishable;
Their construction differs but their effect is the same.

Beyond the gate of experience flows the Way,
Which is always greater and subtler than the world.
(Lao-Tzu, Chapter 1)

With these words, Lao-Tzu, one of the greatest Eastern philosophers, expressed comprehensive echoes in thoughts and research: "The Way," referring to the truth, can be barely described or understood. Indeed, as yet, even modern science cannot fully specify truth. For example, the atomic theory of matter and the periodic table of elements do not allow us to fully understand how or why material objects work, including living beings. Molecular biology does not fully explain how molecules underlie the development and function of living organisms. Neuroscience does not fully reveal how and why the brain functions. And psychology does not fully answer the relationship between the mind and its products. Human knowledge also cannot explain the causality of, or even the existence of a cup or football matches, in terms of scientific (G. F. R. Ellis, 2005), philosophic (Hume, 2000; Silberstein, 2001) or religious (Lama, 2005) perspectives.

1.1.1 General parapsychology/Psi

Similarly, parapsychology is facing this above problem of describing and explaining its subjects. Parapsychology is the scientific study of experiences that cannot be explained by the existing science that we have developed. Generally speaking, according to the book "An introduction to parapsychology", written by Irwin (2004),

[1] Part of this chapter has been presented at the Meeting of Taoism, Thoughts and Science Conference (Shiah, 2007).

the contents of parapsychology include extrasensory perception (ESP), psychokinesis (PK), poltergeist experiences, near-death experiences, out-of-the-body experiences, apparitional experiences, and reincarnation experiences. Extra-sensory perception is a general term used for information acquisition other than by conventional sensory processes of sight, sound, taste, touch and hearing; PK is an ability that influences the environment seemingly by intention or other mental activity alone without motoric intervention; poltergeist experiences refer to movements of objects, noises, fires, water inundations, bites, scratches, pinches, or demonic persecution caused by a deceased person (Irwin, 2004). In addition, the possibility of the healing effect of prayer is also included in this anomalous science (Walach & Schmidt, 2005).

Parapsychologists have carried out a large number of studies examining the possible existence of ESP. The Society for Psychical Research (SPR), founded in 1882 by a group of distinguished Cambridge scholars in the United Kingdom, was the first to scientifically investigate anomalous phenomena. The SPR attracted the most talented people of that time. The earlier investigators paid attention to a variety of *psi* phenomena, such as telepathy, clairvoyance, hypnosis, apparitions and hauntings. *Psi* is a general term including both ESP and PK, presumably working all the time (Carpenter, 2005). The SPR initially developed the study of *psi* phenomena in terms of setting scientific standards, developing methods and accumulating data (Rush, 1986).

Joseph B. Rhine is considered as the father of experimental parapsychology. He and his colleagues conducted the first ESP study about clairvoyance in 1927 at Duke University in North Carolina, USA. Their work was summarised in a book entitled "Extra-Sensory Perception After Sixty Years" (Pratt, Rhine, Smith, Stuart, & Greenwood, 1940/1960). They designed five special cards, which were a star, a circle, a square, a cross, and wavy lines. Participants attempted to guess the order of randomised packs of cards carrying the images of these five symbols. Rhine also developed the statistical means to evaluate the data, as well as a well-controlled experimental procedure in order to eliminate sensory cues. The results of his studies suggested significant effects in telepathy, clairvoyance and precognition respectively. Telepathy refers to mind-to-mind communication via ESP perception; clairvoyance refers to paranormal acquisition of any information directly from a physical source, other than directly from the five senses; and precognition refers to ESP awareness of a future event (Irwin, 2004).

If we regard J. B. Rhine's work as the start of experimental parapsychology, then obviously, experimental parapsychology is really a young science established for less than 80 years. Historically speaking, for example, three major ESP experimental paradigms have been developed in parapsychology, such as the card guessing ESP paradigm in the Rhine centre at Duke University (1927 – 1950); the Maimonides ESP dream paradigm (1962-1979) and the *ganzfeld* technique begun in 1974 (Honorton & Harper, 1974). The Maimonides ESP dream paradigm refers to investigating ESP performance while dreaming – at the Maimonides Medical Centre, Brooklyn, USA (Sherwood & Roe, 2003). The *ganzfeld* technique involves participants experiencing target-related imagery under sensory deprivation conditions (Irwin, 2004). The *ganzfeld* refers to a total field, and this procedure includes a receiver, a sender and targets. The receiver is placed in a reclining chair in an acoustically isolated room and his or her internal somatic noise is reduced by wearing a pair of translucent ping-pong ball halves over the eyes, whilst wearing headphones playing white noise. The receiver also undergoes a series of progressive relaxation exercises at the beginning of this procedure. The sender is also placed in an acoustically isolated room. The sender concentrates on the target and the receiver tries to "receive" that target. The target is a visual stimulus, such as an art print, photograph or brief videotape clip. At the end of the procedure, the receiver is presented with four stimuli and asked to rate to what degree those stimuli match his/her mental images during this procedure.

Robert L. Morris (1942-2004) is respected as an important apostle of academic parapsychology. He held the Koestler Chair of parapsychology in Edinburgh University from 1985 till 2004 and was a central figure in parapsychology for nearly 40 years. One of his major accomplishments was to establish parapsychology as an academic subject. There are currently around 10 departments in the United Kingdom where parapsychology is being studied. Morris promoted topics, such as minimising participants' fraud in parapsychology laboratories (Morris, 1987) and experimental systems in mind-matter research (Morris, 1999) and research methods in experimental parapsychology (Morris, 2001). More of his work will be referred to later. He doubtless succeeded in the attempt to link parapsychology to science. In fact, there are many scholars who have made very valuable contributions to parapsychology and their works will be discussed later.

Some researchers (Alvarado, 2003; J. E. Kennedy, 2003; Morris, 2001; C. Watt, 2005) contended that parapsychologists have done a good job in developing well-controlled methodology to evaluate *psi* phenomena scientifically. Many researchers (Bem &

Honorton, 1994; Bem, Palmer, & Broughton, 2001; Broughton, 2002; Carpenter, 2004, 2005; Dunne & Jahn, 2005; Ertel, 2005; Palmer, 2003; Radin, Nelson, Dobyns, & Houtkooper, 2006; Utts, 1995; Walach & Schmidt, 2005; D. B. Wilson & Shadish, 2006; Wooffitt & Allistone, 2005) consider that there are enough results from studies with rigorous methodology to have shown that the existence of *psi*. Over 50% of introductory psychology text books (N=173) published from 1980-2002 mention these *psi* studies (McClenon, Roig, Smith, & Ferrier, 2003).

1.1.2 Factors affecting or relating to psi performance

1.1.2.1 Aging

Over the years, researchers have noticed that children might be a potential group for demonstrating psi ability (Bourgeois & Palmer, 2002; L. E. Rhine, 1965; Roll, 1997). Many parapsychological studies have focused on investigating the existence of psi in adults, with little research examining psi in children. In practice, there are a lot of difficulties in conducting parapsychological studies with children. The issues in development of psi abilities are little known (Alvarado, 2001; Drewes, 2002). Many experiments designed for adults might not be suitable for children. Adults, obviously, are more available since most researchers are working in universities in which participants are studying. It will be more difficult to get permission from children's parents, as well as from ethics committees.

Although it is not easy to conduct parapsychological experiments with children, children might provide us with particular performances and phenomena (Alvarado, 2001). It has been suggested that psi might occur in childhood (L. E. Rhine, 1965). 148 letters from Dr. Louise Rhine's (1891-1983) more than 30,000 letters about spontaneous psi experiences involved children aged 10 to 18 between 1961 and 1977 (Drewes, 2002). They contained 157 psi experiences and are categorized in Table 1-1. Though only 148 out of 30,000 letters in Dr. Louise Rhine's collection related to the children's psi experiences, the results firstly provide an initial framework for understanding children's tendencies in psi abilities. More studies, such as further investigating those claimed psi abilities or accumulating more data from children, are needed, as well as comparing child psi to adult psi.

Table 1-1 Frequency of experience types

Type of Experience	N	%
Precognitive dreams	82	52
Precognitive intuition and impressions	10	25
Clairvoyance	22	14
Telepathy	16	10
Total	157	100

In a series of studies with children conducted by Van J. G. Busschbach (Van Busschbach, 1953, 1955, 1956, 1959, 1961), children produced significant results in a general extra sensory perception (GESP) test and younger children seemingly performed better than older children. GESP means the participants might rely on clairvoyance or telepathy in the ESP test. The total results were significant ($p<0.05$). Later, several studies indicated a negative relationship between age and psi performance. 1,000 participants aged three to 70 were tested in the GESP task (Spinelli, 1977), although this study was criticized for its statistical methodology (Berger, 1989) and lack of replication (Blackmore, 1984a). The participants below eight years old demonstrated a significant result ($p<0.01$) and the youngest participants aged three to four even showed significantly better scores than the older participants. Similarly, the first graders (aged six to nine) scored better in the ESP task than older children (Shargal, 1987). One hundred and twenty children of age five to 10 were tested on an ESP computer task and younger children did not score significantly higher than older children (Bourgeois & Palmer, 2002). By contrast, significant psi-missing in older African-American children was found. (Psi-missing means an ESP performance is significantly below that expected by chance (Irwin, 2004).

Several possible reasons might account for why children perform better in ESP tests. First of all, children have been considered to be excellent parapsychological experimental participants because of their earlier Piagetian developmental stage, that is, before the concrete operational stage (between age seven and 12) (Spinelli, 1977). During the concrete operational stage, the child begins to reason logically and organize thoughts coherently. That more logical thinking might decrease psi performances is a plausible inference. In fact, non-logical thinking ('creative' thinking) is one of the suggested explanations to account for psi hitting, as will be mentioned later.

Second, cross-modal effects might provide an explanation. Children are easily prone to merge different senses, perhaps, as well as ESP senses, to form their experiences at the same time. Extensive functional connections between the brain areas that promote the different sensory modalities were discovered in the young animals of several species, including human, many of which were lost during maturation through synaptic pruning (Gogtay et al., 2004; H. Kennedy, Batardiere, Dehay, & Barone, 1997; Standring, Ellis, Healy, Johnson, & Williams, 2004). It would make sense to suggest that humans might experience psi early in life, and that pruning of cross-modal connections results in having less psi experience.

Next, as will be noted later, psi occurs in a quiet mental state with a low cortical arousal. One of the most important indicators of a quiet state of mind is through EEG, especially in the α wave (8-13Hz) or below. The normal adult EEG pattern is established between the ages of 25 and 30. The dominant cortical activity gets higher when aging (Davidson, Jackson, & Larson, 2000). According to Davidson *et al.* (2000), at two years old children show their dominant maximum rhythm value of 2Hz in the EEG, while at ten years old children show their dominant maximum rhythm value of 10Hz. The normal adult EEG pattern is established between the ages of 25 and 30, which could reach over 40Hz. Thus, aging might result in a loss of psi abilities due to increased cortical activities resulting in increasing internal somatic noise to interfere with perception of psi signals. In fact, the evidence only indicates that children have lower brain activities than adults. It is not certain that children have a quiet mental state most of the time.

A spiritual approach might explain why children are a potential group for demonstrating psi ability. One study found that psi experience was related to spirituality (J. E. Kennedy & Kanthamani, 1995). One of the meanings of spirituality involves a mentality that is refined, sensitive, naive and non-materialistic. Children are usually considered to be naive, whereas adults mainly become more sophisticated when aging.

Children are more inclined to seek attention and to please adults (Drewes, 2001). This might serve as a real need for children to use psi. Participants' psi abilities might be manifested via giving them a real need for using psi (Broughton, 1988). Finally, children are easily suggestible and tend to be believers in psi experiments, which is a positive characteristic linked to psi performance.

1.1.2.2 Altered states of consciousness

Many attempts have been made to explore the relationship between psi and altered states of consciousness. Relevant studies relating to this issue published from 1882 to 1998 were categorised under seven headings: hypnosis, mediumship, motor automatisms, multiple personality, fugue state, dreaming, and the ganzfeld technique (Alvarado, 1998). Among them, only hypnosis, dreaming and a quiet or drowsy state of consciousness, including the ganzfeld technique, have been studied recently, as will now be presented.

Psi performance occurs best in a quiet state of consciousness (Rao, 2001; Targ & Katra, 2001), suggesting that a quiet mental state has a functional role in facilitating psi performance. One common explanation for this functional role is that it serves to reduce internal somatic noise and increase the psi signal-noise ratio, which is considered to enhance a person's psi performance (Bem & Honorton, 1994). In a review study (Honorton, 1977), ten of the 13 psi studies used relaxation. These ten studies involved 16 experimental series and nine of them had significant results. The Ganzfeld technique can be regarded as involving a quiet state of consciousness similar to a hypnagogic state (Vaitl et al., 2005) with an aim to reduce internal somatic noise (W. G. Braud, Wood, & Braud, 1975; Honorton, 1977; Honorton & Harper, 1974; Parker, 1975). According to the accumulated data, the Ganzfeld technique typically elicited ESP performance at above chance levels (Bem & Honorton, 1994; Bem et al., 2001; Palmer, 2003). With respect to spontaneous psi, 90% of cases occurred during activities requiring minimal cognition, such as sleeping or sitting (Irwin, 1994).

Likewise, within the Chinese tradition there is an important conceptual framework for relaxation - Qigong. Qigong literally refers to energy (Qi) cultivation (gong). Over one thousand methods of practicing Qigong have been developed over thousands of years. It has been claimed that these methods teach people how to manipulate Qi through controlled breathing, movement, and acts of will. Individually, two of the twenty participants who performed a GESP task while practicing Qigong were found to yield a significant result ($p<0.05$) better than mean chance expectation (Lee & Shih, 1993). Note that getting two in 20 "significant" results might be due to the chance. In an operational behavioural definition, a quiet mind after practicing Qigong refers to the "emptiness" of one's mind in a wakeful state and openness to perceptual information (Lee & Chang, 1991). Similarly, some participants performed well in ESP tasks with a reported mind being engaged in a "blank" state (Rao, 2001). It is believed that such "emptiness" may enhance normal perception (Carter et al., 2005; Lama, 2005) and perception of paranormal information (Lama, 2005). Apparently, the claim of Qigong with ESP needs to be further scientifically explained and explored.

According to a review of over 40 ESP studies of dreaming from 1962 to 2002 (Sherwood & Roe, 2003), the overall results indicate a positive finding that participants correctly identified the target at better-than-chance levels. Hypnosis is also considered an enhancer for ESP performance (Ryzl, 1962, 1966; Ryzl & Pratt, 1962). Twenty studies were reviewed to compare psi performance in hypnotic induction and control conditions (E. I. Schechter, 1984). The group under hypnotic induction had higher psi scores than the group in the control condition. This point was further supported by a meta-analysis of 25 studies involving hypnosis (Stanford & Stein, 1994).

An electroencephalograph (EEG) is frequently used to measure the relationship between cortical activity and psi performance. Brain waves are measured by an EEG machine, which records small voltage signals from the scalp (Salinas & Sejnowski, 2001). It is believed by some that psi occurs in a quiet or a rather drowsy state of consciousness with low cortical arousal such as α (8-12Hz), delta (1-3Hz) and theta (4-7Hz) (Honorton, 1977; Honorton, Davidson, & Bindler, 1971; Lee & Shih, 1993; McDonough, Don, & Warren, 1994; McDonough, Warren, & Don, 1989; Stanford & Palmer, 1975; Targ & Puthoff, 1974).

1.1.2.3 Cerebral hemisphere dominance

It has been claimed that one area of the brain involved in psi might be the right hemisphere (Broughton, 1976, 1978; Ehrenwald, 1984; Roll & Persinger, 1998). In particular, it has been claimed that this effect has been observed in a study of the psychic, Sean Harribance (Roll & Persinger, 1998), although it is not observed in 'normal' people (Alexander & Broughton, 2001; Broughton, 1978), Clearly, this issue requires further research.

1.1.2.4 Emotional response

The emotional system might play an important role in interpreting paranormal information (Broughton, 2002). One of the promising ideas is presentiment (Radin, 1997, 1998). One common method is to use the skin conductance response (SCR) to detect future information, such as a shocking picture or a loud noise. SCR refers a change in the ability of the skin to conduct electricity, caused by an emotional stimulus. Another method is to employ slow cortical potentials (SCPs) in the brain to show the significant difference between before a light flash and before a no-flash condition (Radin & Lobach, 2006). The other measures are heart rate (McCraty, Atkinson, & Bradley, 2004a, 2004b; Sartori, Massacessi, Martinelli, & Trissoldi, 2004) and event-related potentials (ERPs) (McCraty et al., 2004a, 2004b). Many researchers have successfully replicated the results (Bierman & Radin, 1997; Bierman & Scholte, 2002; May, Paulinyi, & Vassy, 2005; Radin, 2004), though one study failed to support this idea (Broughton, 2004). The results might reveal a possible explanation for how the emotional system perceives paranormal information (Broughton, 2004, 2006), although such possible explanations cannot entirely exclude the experimenter effect (May et al., 2005).

1.1.2.5 Experimenter effect

Some researchers seem consistently to achieve positive results of psi; by contrast, others appear to have more negative psi findings. A study (C. Watt & Ramakers, 2003) indicates that participants tested by psi-believing experimenters had higher scores on the psi task than those tested by disbelieving experimenters. This is called an experimenter effect. In general, according to a review of studies of experimenter effects (Smith, 2003), there are four ways that the experimenter can affect the results of experiments. The first one is that an experimenter can be biased. Experimenters with more positive attitudes might consciously or unconsciously produce positive psi results to support their beliefs. This bias might lead to errors in designing, conducting and interpreting the study.

The second way is that an experimenter may be fraudulent in terms of committing deception through faked data, allowing participants to cheat during experiments or setting ridiculously weak controls.

The third method involves experimenter-participant interaction. The experimenter might try to affect participants' attitudes, beliefs, motivation and performance in tasks. For example, in a study (R. Wiseman & Greening, 2005), participants watched a videotape that a faked psychic placed a bent key on the table. The verbal suggestion condition was in which the faked psychic suggested that the bent key was bending. Participants were more likely to report that the key was bending in a verbal suggestion condition than those who did not receive any verbal suggestion.

The last possibility involves experimenter psi. Experimenters might use their own psi ability to influence participants' performance. This possibility cannot be excluded, if psi exists. It is still premature to decide this possibility since we do not have firm evidence of psi's existence.

1.1.2.6 Magnetic field

One possible important characteristic of psi information might be related to magnetic fields. Biological cells in all organs and non-biological targets, such as electronic noise random event generators (REGs), radioactive decay detectors and pseudo-random algorithms commonly used in psi research, are capable of emitting electromagnetic radiation (P. Stevens, 1997).

In addition, we live in the earth's magnetic field -- the geomagnetic field, primarily created by the current of molten iron in its inner core. There are two distinct types of information from the earth's magnetic field (Johnsen & Lohmann, 2005). The first one is directional or compass information, such as north and south. The other one, the more complex one, is that magnetic features are subject to several geomagnetic parameters, such as inclination angle and field intensity.

Thus, a common idea is that magnetic fields affect human performance. Much research has focused on the role of magnetic field in affecting human performance as well as psi performance. Some further investigations have discovered that geomagnetic activity might affect people's memory retrieval (Persinger, 2002) and complex perception, such as presences, fears, and odd smells (Booth, Koren, & Persinger, 2005; Persinger & Healey, 2002).

Psi performance might be less effective under higher geomagnetic activity (Dalton & Stevens, 1996; Spottiswoode, 1990). A positive relationship was found between successful psi tasks and lower geomagnetic activity (Berger & Persinger, 1991; Broughton & Alexander, 1997; Persinger & Krippner, 1989), as well as quiet geomagnetic activity (Persinger, 1985, 1989). It is believed that too much magnetic activity might act as a form of noise resulting in difficulty for a participant to perceive paranormal information (P. Stevens, 2002).

In fact, electrical charges form the magnetic field, including the human body in spite of its slight electrical charges. One might think that magnetic field generated by a person affects another person's behaviours or brain activity. It has not been firmly determined that a magnetic field made by a human will affect another person's behaviour. The altered state of one brain was found to cause predictable EEG waves of another distant brain, which may be genetically related (Persinger, Koren, & Tsang, 2003) or not (Richards, Kozak, Johnson, & Standish, 2005; Standish, Kozak, Johnson, & Richards, 2004; Wackermann, Seiter, Keibel, & Walach, 2003). These correlated neural signals were even detected by fMRI (Richards et al., 2005). In Radin's study (Radin & Schlitz, 2005), altered waves of one brain caused predictable EEG waves of another distant brain producing a different mood, such as positive, negative, calm, or neutral emotions. A thought from a healer also caused a predictable EEG waves of another distant brain (Achterberg et al., 2005).

The mode of transmission for the magnetic effect remains unknown in any animals (Johnsen & Lohmann, 2005). Relatively little is known about the neural and biophysical mechanisms that underlie magnetic perception. Primary receptors involved in detecting magnetic information have not been successfully identified in humans.

1.1.2.7 Paranormal belief, personality, intelligence and intuition

Paranormal phenomena are "those which, if genuine, would violate basic limiting principles of science" (Tobacyk, 1988), and paranormal belief is belief in paranormal phenomena. Paranormal belief includes traditional religious belief, psi, witchcraft, superstition, spiritualism, extraordinary life forms, and precognition (Tobacyk, 1988). Later, both negative and positive superstition were suggested to be included in superstition (R. Wiseman & Watt, 2004).

The sheep-goat effect is one of the early concepts developed to understand the relationship between belief and psi (Schmeidler, 1952; Thalbourne, 1981). The sheep group (who believed in the possibility of psi) had a better ESP score that the goat group (who did not believe in the possibility of psi) in a meta-analysis study (Lawrence, 1998). However, it should be noted that believers tend to take artificial coincidences seriously (Brugger & Taylor, 2003) and demonstrate non-logical thinking (Blagrove, French, & Jones, 2006; Hergovich & Arendasy, 2005), false memory (C. C. French, 2003; K. Wilson & French, 2006) and psychological variables (C. C. French, 2003; C. C. French & Wilson, 2006; C. Watt, Watson, & Wilson, 2007; R. Wiseman & Watt, 2006), such as fantasy proneness, dissociativity and hypnotic suggestibility, reports of traumatic childhood and perceived childhood control. They also believe that fake séances contain genuine paranormal phenomena (R. Wiseman, Greening, & Smith, 2003). This effect might be suggested to involve a cognitive bias rather than a motivational bias (R. Wiseman & Smith, 1994), such as an affirmative bias (Blagrove et al., 2006).

One of the correlations with paranormal belief that attracts much attention is religiosity or religious belief, since religion is an important part of human culture and the existence of God/gods has yet to be established scientifically. A number of studies have shown that paranormal belief is correlated with religiosity (Buhrmann & Zaugg, 1983; Hergovich, Schott, & Arendasy, 2005; Orenstein, 2002; Tam & Shiah, 2004; Thalbourne & Hensley, 2001). By contrast, some studies did not support this association (L. Ellis, 1988; Rice, 2003).

In the past decade, personality has been regarded as playing a major role in psi hitting, which, in contrast to psi missing, refers to having the correct target identified beyond chance. Empirical studies have shown extroverts to have higher levels of paranormal belief and alleged paranormal experience (Honorton, Ferrari, & Bem, 1992; Schmeidler, 1982). Further, a meta-analysis of 60 independent studies comprising 2,963 participants was conducted and showed that extroverted people performed better in psi hitting than did introverted people (Honorton, Ferrari, & Bem, 1998), though some literature indicated extroversion was not associated with paranormal belief (Rattet & Bursik, 2001; Windholz & Diamant, 1974). Later, this idea also was supported by additional studies (Morris, Summers, & Yim, 2003; Storm & Thalbourne, 2001). By contrast, social anxiety was found to be correlated with psi missing (Carpenter, 1991; Palmer, 1977). Highly defensive participants were found to tend to score lower than less defensive participants (Haraldsson & Houtkooper, 1995; Haraldsson, Houtkooper, Schneider, & Backstrom, 2002; C. A. Watt, 1994; C. A. Watt & Morris, 1995). Also, high-tension participants performed poorer in ESP tasks (Storm & Thalbourne, 2001).

There are two possible reasons why outgoing participants tend to perform better in psi tasks. The first reason is that outgoing people are more social and seek novelty (Bem & Honorton, 1994; Morris et al., 2003). The other reason might be that outgoing people are more relaxed and comfortable resulting in a lower cortical arousal during ESP experiments (Bem & Honorton, 1994).

Creative personality might be one factor influencing psi hitting (Carpenter, 2004, 2005; Morris, Dalton, Delanoy, & Watt, 1995). 40 creative people (22 musicians and 18 visual artists) were recruited to act as receivers in a ganzfeld experiment and they obtained significant results, with a 37.5% hit rate (Morris et al., 2003). Other studies also reported the positive relationship between ESP performance and creativity (Dalton, 1997; Honorton, 1967; Moss, 1969; Roe, McKenzie, & Anowarun, 2001; Schlitz & Honorton, 1992). It is considered that creative people might be more receptive to perceive visual images related to the targets (Bem & Honorton, 1994).

Intelligent or highly educated participants have been shown to have less paranormal belief (Blum & Blum, 1974; Jahoda, 1970;
cognitive ability might be a critical underlying variable correlating with paranormal belief because that general cognitive ability is negatively correlated with belief in the paranormal (Musch & Ehrenberg, 2002). On the contrary, no correlation between paranormal belief and intelligence was found (Irwin, 1993). This issue needs to be further examined.

Intuition might be a possible predictor of psi abilities (Broughton & Bourgeois, 2001). For instance, business executives are considered to often make intuitive judgments and they had heightened precognitive performance compared to other participants (Dean, Mihalasky, Ostrander, & Schroeder, 1974). A study of Intuitive Trader as a screening tool for identifying intuitive talent was suggested for future research (Broughton & Bourgeois, 2001). More data is needed to support the positive relationship between intuition and psi.

1.1.2.8 Psi training and visual imagery training in psi

Some studies have investigated if psi is trainable. For instance, it has been claimed that psi ability could be trained (W. G. Braud & Wood, 1977; Honorton, 1970; Ryzl, 1962, 1966; Ryzl & Pratt, 1962; Targ & Tart, 1985; Tart, 1966, 1975, 1977b, 1986; Tart, Palmer, & Redington, 1979). By contrast, many researchers (Beloff, 1967; Delanoy, 1986; Fourie, 1977; Gissurarson, 1990; Jackson, Franzoi, & Schmeidler, 1977; Morris, Robblee, Neville, & Bailey, 1977; Stanford, 1977b; Utts, 1995; Vitulli, 1983) do not agree with this assumption. Clearly, this point remains unresolved.

Visual imagery occurs when perceptual information is accessed from memory, giving rise to the experience of "seeing with the mind's eye" (Kosslyn, Ganis, & Thompson, 2001). Visual imagery has been widely used to generate psi abilities (Blackmore & Rose, 1997; George, 1981). During psi performance, participants anticipated seeing images and they then reported experiencing subjective images of targets. For instance, participants were asked to imagine the targets in ESP tasks (Blackmore & Rose, 1997; George, 1982; Honorton, 1975; Honorton, Tierney, & Torrey, 1974; Price, 1973; R. Schechter, Solfvin, & McCollum, 1975), PK tasks (Gissurarson & Morris, 1990; Morris, Nanko, & Philips, 1982), remote viewing (Dunne & Jahn, 2005; Puthoff & Targ, 1976) and in the ganzfeld technique. The results from the ganzfeld technique and remote viewing were considered positive.

In brief, although little is known about child psi, children may be a useful resource to be explored in parapsychology in terms of some relevant factors noted above. This is one of the reasons that children will be recruited in this thesis. Relaxation is helpful for participants during psi experiments. Experimenters should put the participants at ease so as to maximise performance and humanistic considerations (Palmer, 1986). Note that a comfortable environment should be under well-developed controls against fraud. Adopting this premise, several strategies can be used to make participants feel relaxed. The test environment should be pleasant and non-threatening. Good rapport needs to be built up. Experimenters can encourage participants to perform well. Participants can have relaxing practice sessions before experiments. Participants should be made to feel comfortable with all aspects of experiments. The other factor, the altered state of consciousness as in hypnosis and dreaming, will not be included in this thesis since only participants undertaking touching tasks while awake will be investigated.

Experimenter effects unveil an important issue that any psi experimental designs might have some limitations of their controls even under perfect safeguards. Three sources affecting psi performance cannot be entirely eliminated as follows.

Psi ability of the participants or the experimenters:
They might influence each other by using their psi abilities. Given the unknown nature of psi, concerns regarding the aspect of psi influence do not appear to be of immediate importance.

Experimenter's attitude -- believing in psi or not:
This might affect participants' psi performance. However, the details of how this can happen are still unknown (Smith, 2003; C. Watt & Ramakers, 2003). One possible strategy to solve this problem is to allow monitoring of this possibility -- that is, that the experimenter and co-experimenter's beliefs in *psi* should be measured.

Experimenters or co-experimenters cheating, whether deliberately or unconsciously:
Experimenters or co-experimenters could cheat in a variety of ways, such as making detectable marks on the targets, allowing or helping participants to cheat, or even changing the records. The best way to rule out potential fraud is via replication studies by different researchers.

Most results come to an agreement that higher magnetic fields might interfere with psi performance, although the exact role of the magnetic field in affecting human behaviour is not clear. A good idea is to monitor the magnetic field during experiments and keep away possible sources magnetic waves if magnetic detectors are available. Similarly, the emotional response is a good indicator of psi. Suitable instruments to measure the emotional response is needed. Regarding personality and beliefs, the apparent temporary conclusion is that participants who are believers, outgoing and creative seem to have better psi hitting. No research into this issue with children has been undertaken. Given those adult findings, it might give some useful directions for dealing with this issue of the relationship between psi, personality and beliefs in children. It might be plausible to infer that children who are creative or outgoing will have better psi hitting. For that reason, the relationship between children's psi, personality and beliefs in psi will be investigated first in this thesis. Children's beliefs will be collected by questionnaire. Children's personalities might be assessed from interviewing their teachers and school performance records, such as academic and creative record in their schools, if the records are allowed to be accessed.

There is no firm conclusion about the idea that psi is trainable. With regard to visual imagery and psi, their relationship is still obscure. One enduring problem is to explain what and how participants' visual experiences relating to targets consist in. One might ask the questions: How does this visual experience come about? Does target-related visual imagery really constitute real visual imagery?

The issue of seemingly perceiving psi information with a low cortical arousal (below α EEG wave) will not be explored in this thesis. The major reason is due to the limited scope of this thesis to employ the EEG machine.

In conclusion, among the factors affecting or relating to psi performance, it seems that seven factors have a possible link with psi performance: aging, relaxation, emotional response, experimenter effects, higher magnetic field, personality and belief.

1.1.3 The difficulty of parapsychology

Notwithstanding the above, this new scientific subject receives little attention from mainstream science (Alvarado, 2003; McClenon et al., 2003; Odling-Smee, 2007; Schmidt, Schneider, Utts, & Walach, 2004). Empirical data are emerging only slowly. The total amount of work done in parapsychology is equivalent to no more two months work in psychology in total (Schouten, 1998). Parapsychological studies are often criticised and confronted with a voluminous amount of questions. One basic but important question - the existence of parapsychological phenomena - has long been a matter of intense debate. All experimental paradigms in parapsychology are confronted with the issue of replicability by different researchers (Parker, 2003). This is because mainstream science places a high value on replication since it is the basic requirement for scientific research. For this reason, many researchers (Alcock, 2003; Bosch, Steinkamp, & Boller, 2006a, 2006b; Burns, 2003; Jeffers, 2003; Milton & Wiseman, 1999, 2001) have argued that no convincing evidence has supported the existence of *psi*. This problem leads to other serious problems, such as unpredictability, lack of progress, methodological weakness and failure to propose coherent explanatory theories (Alcock, 2003; Burns, 2003; Diaconis, 1978; J. E. Kennedy, 2001, 2003; Marks, 1986, 1987; Morris, 2000; Sarma, 1986). Within this special context in the laboratory, parapsychology is in a difficult situation due to the lack of replication of strong manifestations of *psi* (Palmer, 2003).

1.1.4 Training psi in Chinese culture

More recently, attempts have been made to investigate parapsychological claims in Chinese society. Chinese society seems to incorporate beliefs about a number of remarkable mental practices which can be used to enhance human potential. According to a historical report (T.-C. Chen, 1999), 318 *psi* stories or reports were found among Chinese authorized history, local historical chronicles and historical notes. It is often claimed that exceptional human abilities can be trained using the Qigong practices described earlier. These include abilities such as clairvoyance, out of body experiences, telepathy, precognition, PK, healing, and reincarnation. These abilities seem to go beyond what we would ordinarily expect. Chinese culture is supportive of the potential existence of such abilities and their trainability in some individuals. They would be seen as natural abilities and as involving new principles of nature. Obviously, they require to be further scientifically explained and explored.

Si-Chen Lee is Professor of the Electrical Engineering Department of the National Taiwan University and is the Principal of the most prestigious university in Taiwan. He is a pioneer at the study of exceptional human abilities in Chinese society. His early work was supported by the Taiwan National Science Council to study Qigong (Lee, 1989, 1990; Lee & Chang, 1991). His major findings for Qigong were an enhancement of the brain wave with α rhythm and the emitting of infra-red radiation or absorption of environmental infra-red radiation by will from the hands while practising Qigong. A positive relationship between an enhanced α brain wave in the EEG and telepathy was discovered. He also investigated a Taiwanese man who claimed to be psychic. A very strong magnetic field was measured from the subject's head while performing PK. The maximum magnetic strength was 115 Gauss (the local magnetic field was 0.3 Gauss) when measured at a two cm distance from his right hand (Lee & Shih, 1993).

Lee then began to focus on finger reading from 1993 by way of a developed training paradigm (Lee, 1998). This training paradigm comprised three serial stages of training to have different psi abilities. The entire training paradigm includes the finger-reading ability, connected with the information field ability, clairvoyance and PK training. In the first stage of finger-reading training, a quarter of children appeared to be able to determine the identity of targets by means of directly touching a two-digit number or a complex character varying in four different colours printed using an ink printer on paper. Some Chinese children seemed able to do this and reported that the targets seemed to appear in their minds as a real visual image even when other senses such as vision were ruled out. The other three psi abilities of finger-reading training will be mentioned more in Chapter 2.

No-one has previously demonstrated that ESP and PK can be trained by a serial training procedure. This finger-reading training procedure was first claimed to have apparently shown that ESP and PK might be trained by a serial training procedure. It is therefore worth further investigating this finger-reading effect. Specifically, the possible existence of finger-reading ability gives rise to three important issues. First, the likelihood that ESP is trainable remains unknown. If ESP phenomena are real, we still do not have a reliable method for eliciting them. Lee (1998, 1999) argued that psi ability could be trained step-by-step through the finger-reading training procedures, probably showing a possible hint that psi is trainable. It might be worth investigating how this training procedure might work.

Secondly, the results of ESP studies have generally been found to be elusive, weak, unreliable and lacking in quality (Alcock, 2003; J. E. Kennedy, 2001). For instance, only 1% of remote viewing participants have shown significant results (Utts, 1996). In addition, parapsychologists do not have an agreement that there has been sufficient evidence to support the existence of ESP. Based on Lee's findings, nearly a quarter of unselected participants were capable showing finger-reading ability after training. This is a decisive effect, suggesting that a strong and reliable finger-reading ability might exist.

The third issue is that the quality of the subjective visual imagery reported by participants plays a key role in successfully identifying targets. This might indicate that vivid imagery is a good predictor of finger-reading ability. If finger reading is real, one would expect its manifestations to be predictable.

A possible way to begin would be to examine the first claim of the finger-reading effects, since if it is true and the other claims, such as indirectly touching of a target, a connecting with the information field, or PK, can be explored later. The other claims will be addressed more in Chapter 2. There is, due to the limited scope of this thesis, no attempt to explore the existence of seeing a folded target, seeing a target in a sealed container, the ability of connecting with the information field and PK.

One of the main aims of this thesis is to establish a well-controlled finger-reading procedure for additional finger-reading studies to be undertaken by not only the author but also other researchers. To achieve this goal, before the finger-reading experiments, pilot trials will be conducted and the purpose is to examine whether these modified finger-reading procedures show potential for use in later research. The entire procedure will be empirically re-checked in order to develop its effective barriers against possible cheating in Chapter 3.

To investigate the finger-reading effect with respect to directly touching a target is the major goal of this thesis. If this touch effect is true, the assumptions for this effect are as follows. The assumptions here are not detailed hypotheses; rather, they are suggested points of view for an attack on a scientific problem, suggesting testable directions, and careful experimentation is then needed for the true details to be discovered.

1. Our fingers might be able to detect printing with a very low elevation, even a nearly zero elevation probably, through unknown functions in the fingers. This would be a new and astonishing discovery in the psychology of perception.
2. The touch effect might involve some new means of communication beyond those presently understood, such as clairvoyance or precognition.
3. In fact, no one has produced any plausible or satisfactory explanation for the finger-reading effect or any new means of communication. The most difficult aspect is whether to attribute it to the first assumption or the second assumption. This effect might involve *both* exceptional tactile ability *and* some new means of communication.

With regard to the first assumption, the limits of relief recognition needs to be determined first, for which detailed description and experimental results can be seen in Chapters 2 and 4. If we can know the limits of relief recognition, then we can investigate possible paranormal aspects of the finger-reading effect later in having ruled any possible role of tactile acuity.

A new function of fingers or a new means of communication will need to be reconsidered and further explored, if fingers identifying printings with an elevation much below threshold is found in later research. If it is real, further investigation, such as indirectly touching a target, can be done later as studying it can tell us about exploring exceptional performance and how to enhance this. Theories can then be developed to account for this finger-reading effect.

1.2 Research objectives of this dissertation

There are four major objectives of this thesis. The primary objective of the studies is to test whether finger-reading ability exists under well-controlled conditions. No-one has replicated Lee's results, which supposedly show the authentic existence of the finger-reading effect. In mainstream science, scientists regard replication as a basic standard, proving the existence for the subject of their study. In such a case, replication could be the best answer to support that a finger-reading effect might exist. Replication is also suggested to be the best way of eliminating error and fraud (Alcock, 2003). If the finger-reading effect can be replicated under robust and credible conditions, then perhaps more research resources could be attracted to investigating the possibility of exceptional and parapsychological finger-reading abilities.

However, before conducting finger-reading experiments, this thesis firstly aims to modify the finger-reading training. The first stage deals with avoidance of fraud and consideration of other factors influencing psi. The second stage moves on to identify relevant research questions and the design of effective methods for answering those questions. The third stage comprises pilot studies. These stages will be described in more detail in subsequent chapters.

The second objective is to determine the limits of tactile relief recognition, with an aim of ruling out the possibility of tactile cues of raised targets being used. Is this finger-reading effect a demonstration of tactile acuity performance or an exceptional performance? The finger-reading task used in Lee's studies was ink-printed text, which is in a range of 1-20 microns (0.001-0.02 mm in elevation). Usually, the paper absorbs most of the ink. One might expect that this ink-printed text is near zero in elevation and this will be precisely determined in Chapter 3. In particular, the author will examine the extent to which characters on a sheet of paper must be elevated above the plane of the paper in order for them to be recognisable by touch. Studies of an elevation of 0.5 mm have been shown to lead to correct recognition in normal sighted adult people (Vega-Bermudez & Johnson, 2001; Vega-Bermudez, Johnson, & Hsiao, 1991). The blind can easily "read" Braille raised dots with a 0.48 mm elevation after substantial training. To date, the elevation between 0.48 mm and zero has not been explored. One previous study has shown that normally sighted people can discriminate Braille patterns of 0.3 mm in elevation (Grant, Thiagarajah, & Sathian, 2000). The author hypothesises that relief recognition below 0.3 mm will be demonstrated. To test these hypotheses, a study will be conducted using different levels in the relief recognition task.

The third objective is to test the modified finger-reading training procedures with children. Two studies will investigate the participants' performance when directly touching targets printed in four different colours.

The fourth objective is to propose a three-stage model of ESP training. To test this training model, investigators can choose one type of ESP performance to run this ESP training model.

In sum, given the long road ahead, in this thesis, the challenge is to see if psi can be observed and described. The principal aim of the former is to support if psi exists, while the latter is more concerned to find out how psi works. These research efforts therefore tend to focus on identifying the existence of a finger-reading effect and constructing a framework to explain this effect. This phenomenon, if it exists, must first be given a theoretical explanation before future research into its nature can be undertaken. The experiments in this thesis may enable goals that help with formulating testable theory, attracting more appropriate resources to target at psi. Consequently, in the context of the problem of constructing a well-developed ESP theory, the investigation of finger-reading in this thesis might also give us a chance to achieve this goal. Even if it turns out to be a result of cheating or a completely misconceived quest, the study of finger-reading is worth carrying out because at least it will let us know whether claims about finger-reading can be supported.

1.3 Outline of this thesis

This thesis presents the development of a well-controlled finger-reading training paradigm and three experiments aimed at investigating the finger-reading effect.

Chapter 2 presents a review of the finger-reading effect. Finger-reading studies in the East and West will be reviewed with a view to identifying proposed questions in this thesis. In addition to the ESP explanation, tactile acuity might a possible explanation for the finger reading effect. Thus, this Chapter moves to discuss tactile acuity, factors affecting tactile acuity and the cross-modal effect of touching. The function and limits of tactile recognition will be discussed. That tactile acuity can be affected or enhanced in a variety of ways will be shown. This reviewed information will then be considered in later experiments

Chapter 3 presents a review of fraud and safeguards. This review gives rise to an abundance of useful information for scrutinising the current finger-reading training procedures and designing modified finger-reading training procedures using good controls. Although reviewed finger-reading papers reveal positive results, a discussion of methodological issues will follow, which will point out the lack of well-controlled conditions in all reviewed studies. It is suggested that finger-reading needs to be further investigated under stringent conditions. Then the Chapter moves to consider the development of a well-controlled finger-reading training paradigm.

Chapters 4 through 6 present three studies. The first study is an experiment to assess the limits of tactile relief recognition. The second and third studies involve an attempt to test if finger-reading is valid in terms of using unselected participants and selecting possibly talented participants.

The final Chapter of the thesis contains a summary and discussion of the overall findings from the three experiments. A proposed ESP training model will be suggested for future research.

Chapter 2. Finger reading

In this Chapter, the author reviews studies of the finger- reading effect with a view to identifying the proposed questions and designing effective methods suitable for use in subsequent studies[2]. This Chapter begins by discussing studies of finger-reading which have been conducted in China and in the West. It then moves on to discuss in detail studies which have been carried out in Taiwan. Studies of this phenomenon have been running for over 10 years in Taiwan. A quarter of children, after finger-reading training, appeared to be able to determine the identity of targets by means of directly touching a flat target varying in four different colours printed by an ink printer on paper. In the West, one study indicates that the fingers might read printing on paper without sight, while all reviewed studies find that fingers alone can discriminate colours on paper.

Tactile acuity might be an alternative explanation to ESP-based explanations of finger-reading. Thus, the finger-reading effect might have involved exceptionally heightened tactile ability. Before evaluating the limits of tactile relief recognition, the author first focused on the palm of the hand and its receptors, especially in the fingertips. A brief attempt was made to review the facts about tactile acuity. Tactile perception has a special role in the working of the body. That the function of skin and sensory receptors in the fingers are responsible for identifying an object was argued. The limits of tactile acuity and methods with equipment designed to measure it was discussed. The summary was given together with suggestions for remaining Chapters.

2.1 Introduction and review of "finger reading"

Attempts have been made to explore possible exceptional human abilities in Chinese societies. Among them, finger-reading ability has been intensively studied by Si-Chen Lee from 1993. A quarter of children, after finger-reading training, appeared to be able to determine the identity of targets by means of directly touching a two-digit number or a complex character varying in four different colours printed by an ink printer on paper. Some Chinese children seemed able to do this when other senses such as vision were ruled out. This "touch" effect has also been reported occasionally in Western experiments for more than a century. The first report of finger reading was published in Russian scientific literature in 1898 (Novomeysky, 1965). Since then, several studies have been conducted to explore this effect. Though

[2] The main body of this Chapter and Chapter 3 regarding the review of finger-reading studies had been published in the European Journal of Parapsychology (Shiah & Tam, 2005) (Appendix 1).

results of Western studies apparently showed positive results, poor experimental design was used in most of the studies (M. Gardner, 1996; Kaiser, 1983). In addition, many of the participants who claimed to have this ability were found to be cheating, e.g. peeking at targets (M. Gardner, 1966). The last Western study of finger reading was undertaken in 1992. Since then, no further research about finger-reading effect has been conducted in the West.

In fact, the finger-reading effect is also subject to criticism in Taiwan (Du, 2005). Does finger-reading ability really exist? Could it just be an example of a performance using tactile cues? Before addressing those questions, we had better take a look at finger-reading studies in the East and the West. In what follows, finger-reading studies in the East and West will be reviewed.

2.1.1 Studies of finger reading in China

On 11th March 1979, a boy aged 12 was reported by the Sichuan Daily in mainland China as seemingly possessing an "ear reading" capability, i.e. he was able to recognise characters written on a piece of paper screwed into a ball and put into his ear (Chien, 1981; Eisenberg, 1985; M. Gardner, 1996). Since then, hundreds of Chinese children have been reported as appearing to possess this ability. Sometimes a folded paper involving Chinese characters was placed into children's hands or armpits. One of the more recurrent claims of possession of exceptional ability was for a finger-reading capability (Lee, 1998; Wang et al., 1989). Empirically, it was further reported that this ability could be induced by intensive training. Out of forty children of ages ranging from five to fourteen, 15 appeared to show this touch effect after between three and ten training sessions (S.-L. Chen et al., 1989). In this training programme, children were instructed to use their fingers directly to touch a paper with written Chinese characters. It was even claimed that children seemed able to read characters within folded paper after more training. The children reported that the targets seemed to appear in their minds as a real visual image even when other senses, such as vision, were ruled out. The researchers assumed this to be a demonstration of something like ESP (L.-R. Lo et al., 1989; Shao et al., 1982; Tien, 1994; Wang et al., 1989).

2.1.2 Studies of finger reading in Western society

Novomeysky (1965) conducted a study employing 80 participants and found that participants distinguished well between colours presented in pairs just by touching, without seeing them. After two or three weeks of exercises, one-sixth of participants learned to recognise five to seven colours just by touching paper. In 1919, the finger-reading effect was investigated by the French novelist, poet and dramatist Romains. Romains' book was translated into English, entitled *Eyeless Vision*, in 1924. Romains investigated French women who claimed they could read without seeing, being blindfolded (Duplessis, 1975; M. Gardner, 1966).

One significant piece of evidence for tactile-colour sensitivity was repeated that participants significantly distinguished black and red paper by touching without seeing ($p<0.05$)(Nash, 1969). Later, in response to Gardner's (1966) criticism of the lack of control of the peeking problem, two studies have taken the appropriate precautions against peeking. A bibscreen box and blindfold were used to guard against peeking and the result of the discrimination of a pair of colours on the paper was found to be significant (Zavala, Van Cott, Orr, & Small, 1967). In Zavala et al's study, the blindfold used was a small Halloween mask. The eyeholes were covered with adhesive tape and the procedure was approved by a professional magician to guard against possible peeking. Likewise, a head box constructed of 3/8-inch thick plywood has been employed to prevent peeking (Nash, 1971). This box fitted over the participants' heads and rested on their shoulders and came completely under the chin to fit snugly around the neck. He found the same positive results as in his previous study of 1969 ($p<0.001$).

A similar result was found among blind people. A 30 year old blind woman, who had been totally blind since the age of 18, discriminated four colours on paper with a significant result ($p<0.001$) (Moss, Gray, Hubacher, & Bush, 1972). Both blind and normally sighted people were found to be able to discriminate colours by touch on paper (Duplessis, 1978).

2.1.3 Studies of finger reading in Taiwan – Lee's studies

This finger-reading effect caught the attention of Si-Chen Lee. He gathered a research team to study this touch effect and developed a four-days-a-week, two-hour per day finger-reading programme to study these phenomena in Taiwan from 1993 onwards (Lee, 1998, 1999, 2002, 2003; Lee & Chang, 2001; Lee, Chen, & Tang, 2000; Lee, Tang, & Kuo, 2004; Tang, Lee, & Hsu, 2000). To explain the whole finger-reading training processes, the three stages are displayed graphically as a flowchart in Figure 2-1. Figure 2-1 is not suggested as a detailed training process; rather, it is an introductory perspective for the whole training processes developed over ten years.

Relaxing stage:

Relaxation (meditation practice) and visual image practice

First stage of training (Finger-reading):

A. Practising touching a number varying in four different colours (attempting to train participants to see a transparent screen or pattern overlaying the field of vision)

B. Practising touching a complex character varying in four different colours (attempting to train participants to see an opaque screen overlaying the field of vision)

C. Practising touching a special (sacred) word, such as Jesus or Buddha (seeing a brightness, seeing a bright person or hearing voices, instead of seeing characters themselves)

Second stage of training (Clairvoyance):

Practising touching from outside of a character within a folded paper or a container

Third stage of training (PK):

PK training (such as breaking a match in a sealed black container)

Figure 2-1. The whole finger-reading training processes

Briefly, the research team conducted a variety of training and testing procedures, and found that children, aged between seven and thirteen, were the easiest to train. Si-Chen Lee trained adults at first as well, but they seemed to benefit little from this training process and failed to show any positive results. It appeared to be very hard for adults to learn how to visualise targets during the training process. The first stage of finger reading training is to practise touching a number varying in four different colours, with an attempt to train participants to see a transparent screen or pattern overlaying the field of vision.

A very interesting finding was some of the children who subjectively reported seeing an opaque screen in their minds seemed to be able to see brightness -- to see a bright person or hear voices while touching special words, such as Jesus or Buddha, printed in Chinese, English, Tibetan, Hebrew or Arabic, without seeing the words themselves (Lee, 2002, 2003; Lee & Chang, 2001; Lee et al., 2000; Lee et al., 2004). This effect was only found to accompany sacred words or symbols, referred to as a "connecting with the information field" (Lee et al., 2000). Physicists have found that four major fields, such as a strong interaction field, a weak interaction field, a gravitational field and an electromagnetic field explain the physical world. In addition to these four fundamental fields, Lee *et al.* (2000) suggested that a form of information field exists in which people can connect with special visual and aural experiences through directly or indirectly touching sacred words by means of finger-reading ability.

Next, in the second stage of finger-reading training, the children were asked to touch from outside a target within a folded paper. Moreover, sometimes the children were trained to touch a black container (for holding a photographic film) containing a target within a folded paper with a positive result.

Finally, in the third stage of finger-reading training, psychokinesis, bending a metal rod or breaking a match, was trained (Lee, 1999). Two of the participants demonstrated PK.

As mentioned in Chapter 1, only the first stage of finger-reading training will be included in this thesis. The first stage training procedures can be illustrated briefly as follows: First, the children were given imagery exercises. The children were trained by letting them touch a paper directly which bore a two-digit number or a complex character printed in four different colours from an ink printer. This training included a "dark" condition in which the paper with its character was put into a dark bag where it could not be seen. Then they were asked to imagine that they could see the numbers, characters or words while touching them. The children were encouraged to practise touching and visual imagery during this training process. The procedural training details will be covered and discussed in Chapter 3.

The grand total of all participants in Lee's studies was 216 participants, aged seven to thirteen. They were recruited from different elementary schools during the years 1996 to 2004. The average success rate at recognition (by $p<0.05$ criterion) by means of directly touching an unseen paper with a two-digit number or a complex character varying in four different colours was approximately 24% (41 out of the 173 participants who went through the whole training programme). The dropout rate was about 20% (43 participants). The major reason for leaving the training programme was that the children felt the programme was somewhat tedious and time-consuming.

The children for whom the techniques seemed to be successful reported that visual experiences had accompanied their successful trials. They reported visual images appearing as if from the real world. They reported seeing a "transparent screen" like a mist, with a floating patch or pattern overlaying their field of vision. Some of the children experienced the coloured targets as a distinct form of imagery like an "opaque screen" masking the normal visual image. The quality of the screen reported by participants seems important for this touch effect. Children appeared to recognise easily complex characters or other complex symbols after seeing an opaque screen. The experience of this opaque screen in the mind correlated highly with correct recognition. It might be trained by touching a complex character, producing a more complex visual image display in the children's minds. The shortest training time was only 20 minutes.

2.1.4 Overall findings

All studies reviewed suggest that fingers might be able to detect colours on paper. With respect to recognising printing, only one Western study, but all the Eastern studies found significant results.

One of the major differences between Western and Eastern studies is that Lee developed formal procedures targeted at children for developing finger-reading ability. According to this training paradigm, a visual experience accompanied with the correct answers was suggested to play the key role in helping participants successfully identify targets. This might indicate that reporting seeing a visual screen might be a good predictor of finger-reading ability. This claim is worth investigating. If finger-reading ability is real, one might expect its manifestations to be predictable.

Note that well-controlled conditions are of particular importance while conducting this investigation, as will be discussed later.

The other difference is that only children, and not adults were recruited as participants in Eastern studies. As aforementioned, children seemed to perform better than adults did in Lee's finger-reading studies, revealing a reason for exploring ESP and children. The cause of children performing better than adults did in Lee's studies is unknown. This result is similar to the reviewed studies in Chapter 1 showing a negative relation between ESP performance and aging, suggesting that children might be a gifted group for acquiring ESP.

2.2 Two alternative explanations

One possible explanation for the finger-reading effect is ESP. This issue will be dealt with in later Chapters in terms of running finger-reading experiments under well-controlled conditions. One of the main purposes of this thesis is to examine the extent to which characters on a sheet of paper must be elevated above the plane of the paper for them to be recognised by touch. The author will attempt to determine the limits of tactile relief recognition. If we can know the limits of tactile relief recognition, the result could help to rule out the performance being due to exceptional tactile acuity.

From the reviewed results of empirical tactile measures, tactile relief recognition is similar to the finger-reading task. However, the elevation of raised patterns between 0.49 mm and zero has not been explored so far. One piece of evidence indicates that people may have abilities within this range (Grant et al., 2000). Specifically, the author will hypothesise that relief recognition of below 0.5 mm will be observed. This study will be developed fully in Chapter 4 in which six levels of tactile relief recognition task will be suggested and developed. Thus, the limits of tactile recognition can be determined and a value below threshold of tactile relief recognition will be applied to produce the touch samples used in a later experiment, with the aim of ruling out the possibility of using tactile cues.

Another important issue, which will be discussed later, is that tactile acuity can be affected or enhanced in a variety of ways, such as aging, gender, finger size, eccrine sweat glands, skin conformance, blindness, deprivation of light, hand skills, acute hand deafferentation, visual-tactile interaction, visual imagery, temperature, and stochastic resonance effects.

2.2.1 The function of skin, receptors and glands in the fingertips and tactile acuity

The function of skin, tactile receptors, neuroendocrine receptors, thermal receptors and eccrine sweat glands will be discussed. Nociceptors responsive to pain will be excluded since they are less relevant to the identification of touching targets.

2.2.1.1 Skin

The skin is the largest body organ. The skin comprises of two layers, from deep to superficial as follows: epidermis and dermis. We have learned that the skin, particularly the epidermis layer, serves many important functions, such as controlling body temperature, forming an effective barrier against environmental intrusion (microbial invasion, thermal and ultraviolet radiation damage, etc.)(Slominski & Jacobo, 2000; Standring et al., 2004) and acting as an important neuroendocrine organ (Slominski & Jacobo, 2000).

The hands are covered with two major kinds of skin. These are thin, hairy, skin, which covers the dorsum of the hand, and thick, hairless skin, which forms the surfaces of the palms of the hand, and palm side surfaces of the digits. Epidermal ridges of the palm-side surfaces of the digits can be clearly observed, which functionally increase the gripping ability of hands to prevent slipping, the distribution of pressure and equal stretching ability (Slominski & Jacobo, 2000; Standring et al., 2004).

2.2.1.2 Receptors and glands in the fingertips

2.2.1.2.1 Tactile receptors

The major receptors of the fingertips are shown in Figure 2-2. Type 1 slowly adapting afferents end in the Merkel cells in the basal layer of the epidermis, and are sensitive to texture and form perception. The basal layer of the epidermis, adjacent to the dermis, is the layer where cell proliferation in the epidermis takes place. The Merkel cells are easily observed since they can be distinguished histologically from other cells (Standring et al., 2004). Rapidly adapting afferents end in the Meissner corpuscles located in the dermal ridges that lie just beneath the epidermis and are responsive to dynamic skin deformation and low frequency vibration. The Meissner corpuscles can also be easily observed in tissue samples. No relationship between the Meissner corpuscles and the pattern intensity of the digit ridge, such as ridge count and ridge width, is found (Dillon, Haynes, & Henneberg, 2001). In the same way, the relationship between the pattern intensity of the digit ridge and the other three tactile receptors is not clear.

Pacinian afferents end in the Pacinian corpuscles located in the dermis and deeper tissue fine reactive to deformation and are visible to the naked eyes (Standring et al., 2004). Type 2 slowly adapting afferents end in the Ruffini corpuscles located in the dermis and are receptive to the speed and direction of an object's motion. Type 2 slowly adapting afferents were not detected in monkey hands, therefore, they have been less studied than other afferent types (Johnson, 2001). These four kinds of tactile receptors are more densely innervated in the digits than in the palms. There are also nociceptors sensitive to pain and thermoreceptors sensitive to cold and hot.

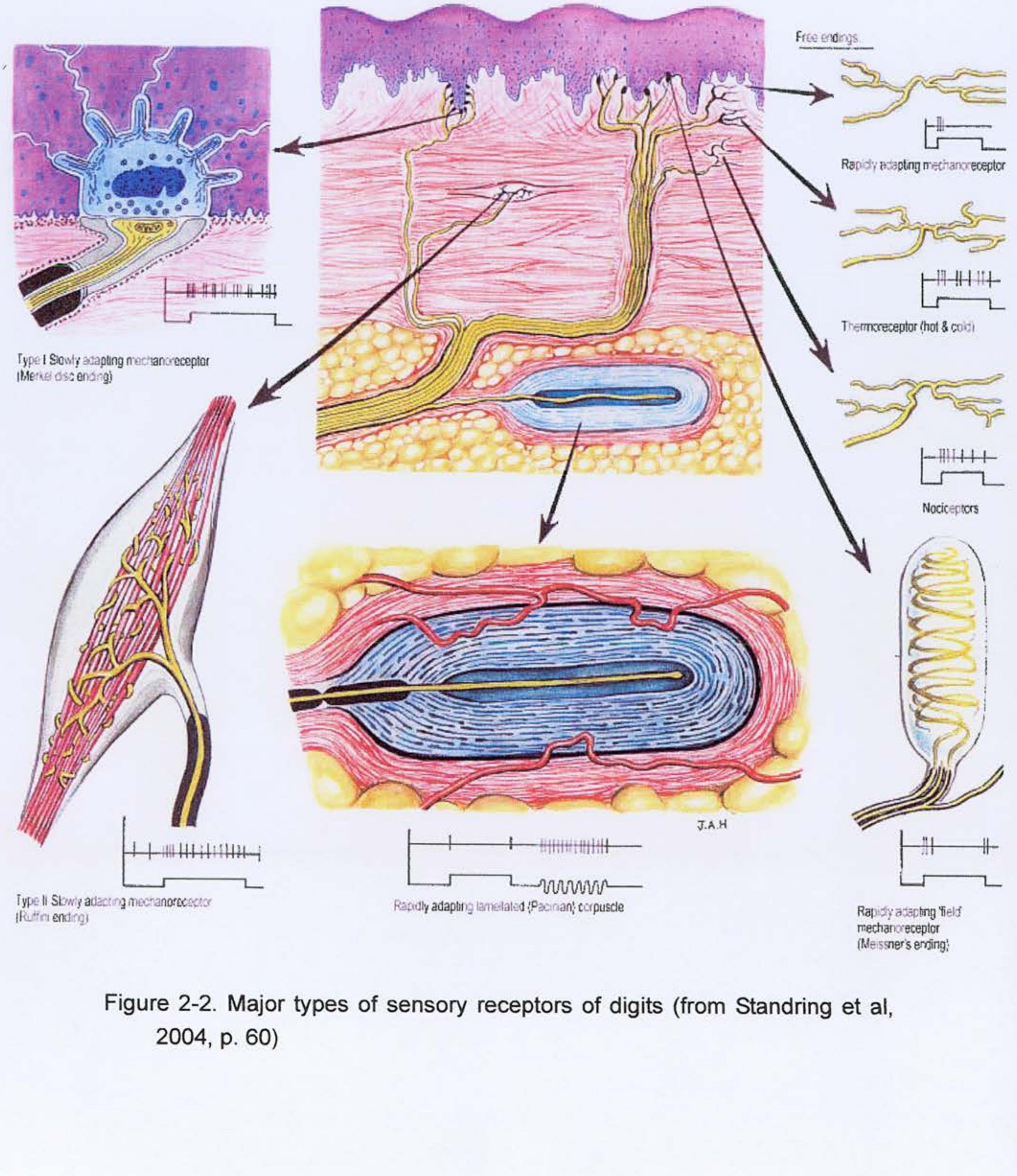


Figure 2-2. Major types of sensory receptors of digits (from Standring et al, 2004, p. 60)

2.2.1.2.2 Neuroendocrine receptors

According to the study of neuroendocrinology, the skin is identified as having a remarkable function as a target of neuroendocrine signals. Over twenty different neuroendocrine receptors, a source of hormones, four kinds of cutaneous neuroendocrine systems and one regulator of cutaneous vitamin D production were found in the skin (Slominski & Jacobo, 2000). Interestingly, the light-sensitive pigment cells in the skin of many vertebrates and invertebrates react to light (Arnheiter, 1998). The human skin also responds to light but unconsciously, especially the ultraviolet-B (UVB) light (290-320nm) and ultraviolet-A (UVA) light (320-400 nm) wavelengths, resulting in the production of vitamin D and thus affecting skin pigmentation. The level of skin pigmentation works to prevent UVB and UVB radiation damage (Slominski, Tobin, Shibahara, & Wortsman, 2004), in which whiter skin absorbs most of the energy from light (Slominski & Jacobo, 2000).

One of the very important questions in this thesis is: can our skin see? To the best of our knowledge, retinal photoreceptors are only found in rod and cone cells, which contain light absorbing photopigments. Evolutionarily, the pigment cells in the skin may be linked to the precursor of the photoreceptor cells in the eyes (Arnheiter, 1998). The light absorbing photopigment has not been found in human skin, although, retinal photoreception is not exclusive to just rod and cone cells (Fu, Liao, Do, & Yau, 2005), as was observed in the salmon's eyes (Soni, Philp, & Foster, 1998). The existing evidence is that the human skin cannot see.

2.2.1.2.3 Thermal receptors

The thermal quality of an object is an important clue for providing important information for recognising an object while touching it, which senses the different temperature between air, the object and the skin. Thermal receptors are very sensitive to temperature change between air, objects and the skin (34℃) (E. P. Gardner & Kandel, 2000). There are two kinds of thermal receptors: cold and warm receptors. Cold receptors are responsive to 5-40℃, whilst warm receptors are reactive to 29-45℃ (E. P. Gardner & Kandel, 2000; Patapoutian, Peier, Story, & Viswanath, 2003). Pain is perceived when the body is confronted with temperatures above 45 ℃ or below 5 ℃. It is not clear how the thermal receptors serve a function to identify an object.

2.2.1.2.4 Eccrine sweat glands

Eccrine sweat glands are located from skin surface to lower dermis and are activated by emotional and cognitive activities (Critchley, 2002), resulting in the secretion of water, electrolytes and mucin (Sato, 1977). The highest density of eccrine sweat glands is on the palmar side of hands (approximately 400/mm^2) (Critchley, 2002), which secrete greater sweat concentration (Critchley, 2002; Freedman, Scerbo, & Dawson, 1994). Eccrine sweat glands serve many functions, such as thermoregulation, mechanical friction, motor preparation, movement and emotional expressions (sweating), as well as serving as an indicator of cognitive activities, such as attention (Critchley, 2002). No difference of sweat rate between men and women has been found (Green, Bishop, Muir, & Lomax, 2000)

2.2.1.3 Tactile Acuity

2.2.1.3.1 The function and limits of tactile receptors in the fingertips

Tactile perception at the fingertips is a critical component of the sensory and motor function in the hand (Johnson & Hsiao, 1992). It is one of most delicate functions in humans (Levine, 2000). As a matter of understanding the limits of finger tactile acuity, neurophysiological and psychophysical studies of finger tactile acuity are reviewed. Firstly, there are four fine cutaneous mechanoreceptive afferent neuron types in the fingertips, summarised in Table 2-1, mainly from a review of neurophysiological research (Johnson, 2001), unless otherwise specified.

Table 2-1 Function of the four types of afferent neurons

Afferent neuron types	Function
Type 1 slowly adapting (SA1): afferents end in the Merkel cells; in the basal layer of the epidermis; about 100 Merkel afferents per cm^2 at fingertip	1.Texture and form perception: sensitive to indentation depth, such as points, edges and curvature, especially when fingers scan a surface up to at least 80 mm s^{-1} (performance decreases when fingers do not scan the surface) 2.Resolve spatial detail of 0.5 mm, although their receptive field diameters are 2-3 mm; perception of coarse textures, which elements more than 0.1 mm in size (Bensmaia & Hollins, 2003) 3.Respond to skin indentation to depths of at least 0.15 mm 4.Only SA1 providing a neural image of the human threshold for object orientation at 4 to 5 degrees 5.Independent of contact force, reliable discriminate surfaces with dots or ridges differing by 2% of spacing
Rapidly adapting (RA): afferents end in the Meissner corpuscles; in the dermal ridges that lie just beneath the epidermis; about 150 Meissner afferents per cm^2 at fingertip	1.Sensitive to dynamic skin deformation: four times more sensitive than SA1 (less than 0.04 mm); begin to saturate at about 0.1 mm, and insensitive to the height above 0.3-0.4 mm; receptive field diameters are 3-5 mm 2.Detection of low frequency vibration; most effectively at signaling sudden forces that act on the objects held in the hand working an important function of provision of feedback signals for grip control 3.Perception of fine textures, which particle sizes less than 0.1 mm, is mediated by vibrotactile channels (RA and PC both)(Bensmaia & Hollins, 2003)
Pacinian (PC) afferents end in the Pacinian corpuscles; in the dermis and deeper tissue with as many as 70 layers; about 350 per finger and 800 in the palm	1.Sensitive to deformation of nm range; responds to 10 nm (0.00001 mm) of skin motion or vibrotactile stimulus (at less 200 Hz) 2.Almost no spatial resolution 3.Produce a high-fidelity neural image of transient and vibratory stimuli
Type 2 slowly adapting (SA2) afferents end in the Ruffini corpuscles; in the connective tissue of the dermis; less densely than either SA1 or RA (unknown density)	1.Perception of the direction of object motion or force when motion or direction of the force produces skin stretch 2.Perception of hand shape and finger position through conformation along with muscle spindles and possibly joint afferents

These four types of afferent neurons need to work together to achieve an accurate identification while touching a target. It is contended that tactile spatial perception is like blurred visual spatial perception (Craig & Johnson, 2000; Vega-Bermudez & Johnson, 2004). Based on Johnson and Hsiao (1992) and Johnson (2001), during finger reading, for example, the SA1 system might provide a high-quality neural image of the spatial structure of the paper and surfaces of a relief target that is the basis of form and texture perception. Secondly, the RA system might provide a neural image of motion signals from the whole hand. Then the brain extracts information for grip control and information about the motion of the target contacting the skin.

Thirdly, the PC system might provide a neural image of vibrations transmitted to the hand from the paper contacting the hand or, more frequently, the target grasped in the hand. For RA and PC systems, as the exploring fingers scan the target (a finely textured surface), vibrations are produced in the skin. These vibrations are then transduced by rapidly adapting RA and PC systems. On the basis of this vibrotactile signal, these textures are perceived. Fourthly, the SA2 system might provide a neural image of the skin stretched over the whole hand, sensing proprioception such as muscle length, muscle force and joint angle, which is called stereognosis. Spatial information is integrated to produce the perception of three-dimensional form, derived from many two-dimensional image form fingers' tactile and proprioception receptors (Johnson, 2001). To date, it is not clear how this function works (Craig & Johnson, 2000; Proske, 2005).

2.2.1.3.2 Tactile central neural pathway

The tactile neural pathway can be summarised from E. P. Gardner and Kandel (2000) as follows. First, tactile sensation and limb proprioception are transmitted to the thalamus. Touch then is mediated by thalamic neurons and sent to the primary somatic cortex in the postcentral gyrus, where the information of touch is integrated. Our sense of touch is exquisitely good on our hands and face, and less so on our abdomen. It has been estimated that about a hundred times as much cortical tissue is devoted to similarly sized regions of the fingers as compared with the abdomen (Spiro, 2001). The primary somatic cortex S-I contains four cytoarchitectural areas: Brodmann's area 3a, 3b, 1 and 2. These four regions of the cortex are extensively interconnected, so that both serial and parallel processing is involved in higher-order elaboration of sensory information. The S-I projects to the secondary somatic sensory cortex (S-II), located on the superior bank of the lateral fissure. The insular cortex is innervated by neurons from S-II cortex, which then projects to the temporal lobe where tactile memory is stored.

Brodmann's areas 5 and 7 are located in the posterior parietal cortex, which receives input from S-I as well as input from the pulvinar located in the thalamus. Brodmann's area 5 integrates tactile information from receptors in the skin with proprioceptive inputs from the underlying muscles and joints. Brodmann's area 7 receives visual as well as tactile and proprioceptive inputs, allowing integration of stereognostic and visual information. At the end, the posterior parietal cortex projects to the motor area of the frontal lobe and plays an important role in sensory initiation. It has been realised that touching activities trigger other cortices in the brain. The detail of how the central neural pathway processes information provided by the four primary afferent systems described above is not understood (Johnson, 2001).

2.2.1.3.3 Empirical tactile measures

2.2.1.3.3.1 The two-point discrimination threshold

The first common psychophysical measurement is to measure tactile spatial acuity. The two-point discrimination threshold is the most widely used measure (Charron, Collin, & Braun, 1996; Lenzenweger, 2000; Tamura, Hoshiyama, Inui, & Kakigi, 2003). The two-point discrimination threshold varies for different body regions. The smallest receptive fields are found on the tips of the finger. Two forms of the two-point discrimination threshold are used: subjective and objective (Craig & Johnson, 2000). The subjective form is the more commonly used method. Participants are presented with two points of stimulation and are asked to judge whether they feel two points or a single point. In the objective form, participants judge whether one or two points were presented to the skin. The tip of the index finger's mean threshold of two-point discrimination is nearly 1 mm (E. P. Gardner & Kandel, 2000). Even a zero threshold has been found in the two point discrimination task (Johnson & Phillips, 1981). This method was criticised for failure to measure the limit of spatial resolution, lack of control of non-spatial cues (using intensive cues instead of employing spatial cues), and lack of reliability(Craig & Johnson, 2000; Johnson & Phillips, 1981; Van Boven & Johnson, 1994).

2.2.1.3.3.2 Spatial acuity

Several methods other than the first-described method are used for the purpose of measuring spatial acuity validly and reliably. The first one is gap detection. The gap detection method measures spatial acuity. The gap detection threshold (Figure 2-3) is found to be 0.87 mm in the index finger (Johnson & Phillips, 1981).

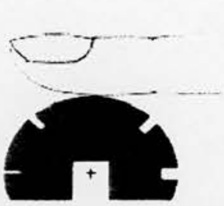


Figure 2-3. Gap detection threshold (from Johnson & Phillips, 1981)

The second measurement is that of grating resolution. The grating discrimination threshold (Figure 2-4) is found to be 0.84 mm in the index finger, which is similar to the gap detection finding (Johnson & Phillips, 1981).

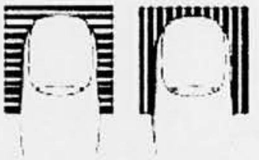


Figure 2-4. Grating discrimination threshold (from Johnson & Phillips, 1981)

The grating orientation discrimination test (GOT) was commonly used and a threshold result of 0.94 mm in the index finger was found (Van Boven & Johnson, 1994). The different bar/groove (gratings) widths used usually were as follows: 0.2, 0.4, 0.6, 0.9, 1.2, 1.5, 2.0, and 2.5 mm (Figure 2-5). Each groove depth was at least 1.5 times the width, which ensured that the skin never touched the bottom. To achieve 75% correct levels of performance is a judgment of a threshold. Blind people were found have a better threshold, at 0.80 mm (Van Boven, Hamilton, Kauffman, Keenan, & Pascual-Leone, 2000).

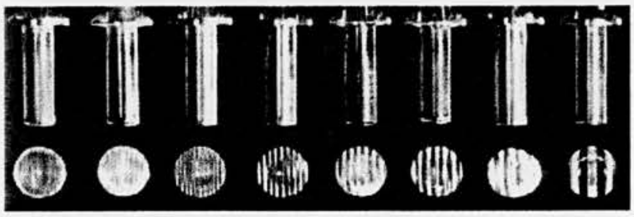


Figure 2-5. Grating orientation discrimination test (from Van Boven & Johnson, 1994)

A high fine resolution level in blind people at 0.50 mm measured by an automatic grating orientation task was discovered (Goldreich & Kanics, 2003). Taken together, the existing data show that no spatial tactile acuity level below 0.50 mm would be discovered.

Note the methods to measure spatial acuity mentioned above just only reveal "static" spatial acuity performance, because participants were not allowed to move their fingers in the tasks. Therefore, the results of spatial acuity could not provide sufficient information for understanding "dynamic" spatial acuity.

2.2.1.3.3.3 Multidimensional scaling tasks

The multidimensional scaling tasks (MDS) are used to investigate the haptic perception of object surfaces (e.g., glass, paper, bamboo, stone and ivory comb) and fabrics (e.g., silk, wool and cotton). Usually, participants have to rate the similarity of the samples, presented in pairs, on a 5-point rating unipolar adjective scale (Picard, Dacremont, Valentin, & Giboreau, 2003; Schellingerhout, Smitsman, & Van Galen, 1998). The idea of this kind of task is the subjective feeling of textual properties.

2.2.1.3.3.4 Abrasive task

Abrasive tasks can be used to evaluate the ability of touch to discriminate fine surfaces. The average particle sizes of abrasive papers were 40, 30, 12, 9, 5, 3, and 1 μm used respectively in one study (Miyaoka, Mano, & Ohka, 1990). The range of the thresholds obtained was between 2.4 and 3.3 μm. Tasks of discrimination of ridge height were also employed in this study. The cross sections of the etched ridges were rectangular and the ridge heights were 6.3, 7.0, 8.6, 10.8, 12.3, 18.5, and 25.0 μm. The range of the thresholds was between 0.95 and 2.0 μm.

2.2.1.3.3.5 Relief recognition

The sunken relief task (Figure 2-6) consisted of palpating the structure of 12 sunken reliefs of 13×13 cm. The structure of the reliefs was milled traces with a depth of 3 mm and a width of 7 mm (Grunwald et al., 1999, 2001). This task could provoke a greater response in the brain. For this reason, Grunwald et al. had used this task to **explore EEG power during touching.**

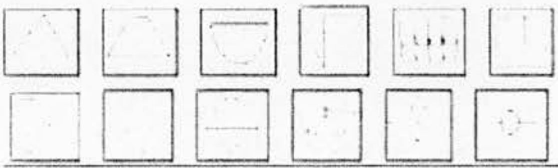


Figure 2-6. The sunken relief task (from Grunwald et al., 1991)

The macrospatial plus microspatial task consisted of aluminium patterns, raised in relief from base plates. In the macrospatial form discrimination task, the stimuli were the uppercase letters T and V (Figure 2-7a). The microspatial task (Figure. 2-7b) was a bar, with or without a 3 mm gap. The length of the bar was approximately equal to the combined length of the lines of each form stimulus. The stimuli for each task were mounted on either end of an aluminium rod (Stoesz et al., 2003). Stoesz et al. had used this task to investigate neural networks during touching.

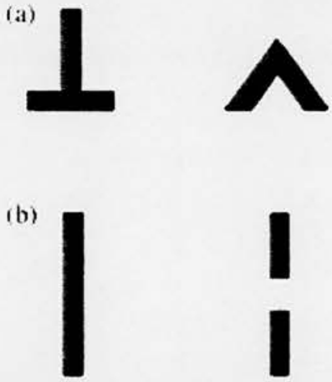


Figure 2-7. The macrospatial plus microspatial task (from Stoesz et al., 2003)

The relief recognition (Figure 2-8) employed a pattern-identification task design using the 26 letters of the English alphabet. Letters raised 1.5 mm above the background with a stroke width of 0.5 mm and height of 3.0, 4.5, 5.5, and 8.0 mm were used. Participants were given no training or feedback. The result showed that letters at 3.0 mm of height were discriminated at a level between above chance and perfect recognition (Johnson & Phillips, 1981).

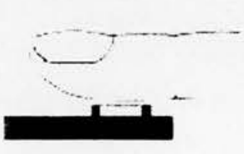


Figure 2-8. Relief recognition (from Johnson & Phillips, 1981)

Another kind of relief letter task consisted of Helvetica capital letters 6 mm in height and ranging in width from 0.5 mm for the letter I to 7.0 mm for the letter W. The stroke width was 0.5 mm and the letters were 0.5 mm in elevation (Vega-Bermudez & Johnson, 2001; Vega-Bermudez et al., 1991). Success at this task also has a significantly positive relation with success at the GOT task (Vega-Bermudez & Johnson, 2001; Vega-Bermudez et al., 1991).

Usually, during relief recognition, participants scanned the letters with repeated, smooth, continuous left-to-right movements (lifting the finger for the return right-to-left movement) using whatever scanning force and speed they liked (Vega-Bermudez et al., 1991). Participants were allowed as many scans as they liked; the average was five (Vega-Bermudez & Johnson, 2002).

2.2.1.3.3.6 Braille characters

Braille characters are a good measure of spatial acuity due to the requirement of resolving fine spatial form (Craig & Johnson, 2000). Braille pattern recognition is based on shapes outlined by the dots (Loomis, 1981). Each Braille cell is made of 6 dot positions, arranged in a rectangle comprising 2 columns of 3 dots each, with each dot separated vertically from one another by 2.34 mm and horizontally by 2.34 mm. Each cell is separated by 6.22 mm. A dot may be raised at any of the 6 positions, and in any combination. Counting the spaces in which no dots are raised, there are 63 (2^6-1) such combinations, since a cell of zero dots is not considered a letter. Each dot has a diameter of 1.45 mm. and a height of 0.48 mm, in the form of the standard Braille alphabet (Figure 2-9). Different languages have different Braille systems, such as the 8-dot system, sometimes, used in Chinese Braille in order to accommodate the larger number of characters.

People who are blind or visually-impaired use their fingertips to determine the location of the raised dots to read Braille. After a long period of training, the average reading speed is about 125 words per minute. Users have better tactile acuity due to Braille-reading experience, the practice effect depending on the specifics of their tactual experience (Grant et al., 2000; Sathian, 2000). One study showed that normal sighted people discriminated patterns of 0.3 mm in elevation, whilst early blind people, who were blind since five years old, discriminated Braille pattern of 0.2 mm in elevation (Grant et al., 2000). Two different patterns were used in this study. The first pattern was a row of three embossed dots. The other pattern Braille consisted of similar patterns in which the central dot was offset laterally. The different dot elevations were 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0 mm.

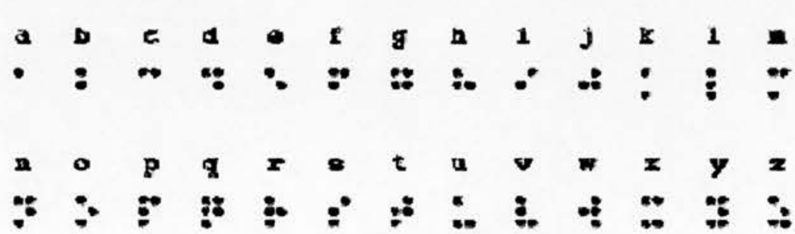


Figure 2-9. Braille alphabet

2.2.1.3.4 Summary of empirical tactile measures

Exploring if our fingers might be able to detect print with a very low elevation is one of the aims of this thesis. To achieve this goal, the limit of relief recognition needs to be assessed first. The tactile task used in Lee's studies was ink-printed text, which is in a range of 1-20 microns (0.001-0.02 mm in elevation). Usually, papers absorb most ink; the ink-printed text is near zero in elevation, as will be verified in Chapter 3. Although detecting range in particle sizes thresholds was between 0.0024 and 0.0033 mm and the range of ridge height thresholds was between 0.00095 and 0.002 mm, it does not suggest that we can recognise a relief recognition task at these thresholds. Actually, it could be expected that one might feel something while touching a target printed by an ink printer if the paper does not completely absorb the ink from the printed target.

The relief recognition task and Braille reading are similar to the finger-reading touching task. For the relief task an elevation of 0.5 mm was used for correct recognition of Helvetica letters in normal sighted people. To the best of our knowledge of the scientific literature, no studies of recognition have used printed text and very few studies have been conducted on the limits of relief recognition. In other words, the elevation between 0.49 mm and zero has not been explored so far. Blind people could perform well in Braille reading of 0.48 mm in elevation after long training.

Braille pattern recognition is based on shapes outlined by the dots encoding each other. One study showed that normal sighted people could discriminate Braille patterns of 0.3 mm in elevation, while early blind people could discriminate Braille pattern of 0.2 mm in elevation. This reveals that letter recognition or recognition below 0.5 mm exists. A limit on the elevation in the recognition task below 0.5 mm is hypothesised. This assumption was acknowledged by the late Professor Kenneth K. Johnson (a touch expert in the medical college of the John Hopkins University, USA) (personal communications, June 15, 2004 and March 27, 2005).

2.2.2 Cross-Modal effect of touching

2.2.2.1 Visual cortex and touch

Many studies have demonstrated a cross-modal effect between touch and vision, showing that there is a notable overlap between the cortical areas implicated in object recognition through sight and touch. This effect was proposed to involve a reciprocal and competitive interaction between multimodal and unimodal areas (Bushara et al., 2003). Two early important studies found activation of the primary visual cortex by

Braille reading in the blind (Cohen et al., 1997; Sadato et al., 1996). Furthermore, trans-cranial magnetic stimulation studies revealed a relationship between visual and tactual cortices in blind people, resulting in distortions and omissions of letters in Braille reading (Cohen et al., 1997; Kujala, Alho, & Naatanen, 2000). These results indicate the evidence for the functional involvement of the visual cortex in tactile processing in the blind (Burton, McLaren, & Sinclair, 2006; Sadato, 2005).

Normal sighted people have shown a similar cross-modal effect as well. For instance, the visual cortex was involved in tactile discrimination of orientation in normal sighted people (Zangaladze, Epstein, Grafton, & Sathian, 1999). Moreover, in studies of normal sighted people with eyes closed, there was an activation of a network of cortical regions associated with somatosensory, motor, visual and, at times, lexical processing in tactile object recognition tasks (Deibert, Kraut, Kremen, & Hart, 1999; Wu, Chuang, Lee, Lin, & Chen, 2003). During the touching activity, the tactile motion was found to activate V5 (MT, middle/medial temporal), which is responsive to moving stimuli (Hagen et al., 2002). The primary and secondary somatosensory areas were activated during tactile imagery (Yoo, Freeman, McCarthy, & Jolesz, 2003). A compelling finding further indicated different roles for the somatosensory and occipital cortices; that is, while making a tactile discrimination, roughness was processed in the somatosensory cortex and distance was related to occipital cortex (L. Merabet et al., 2004).

A pioneering study (Taylor-Clarke, Kennett, & Haggard, 2002) of the visual-tactile interaction was conducted to explore the validity of this mechanism. The subsequent event-related potential (ERP) was used to demonstrate an enhancement of primary somatosensory cortex activity while participants viewed the arm to be touched without seeing the touching tool, which implies that vision modulates cortical processing of tactile perception. These somatosensory areas might be adaptive to the sense of touch for the information to be gathered from viewing the hands; this process lowered tactile discrimination thresholds. The region known as 'lateral occipital complex' is involved in this process, suggesting that visual cortical areas are also involved in processing in other sensory modalities (L. B. Merabet, Rizzo, Amedi, Somers, & Pascual-Leone, 2005).

2.2.2.2 Frontal lobe and touch

Relationships between power of theta waves in the EEG in the front region and working memory have been pointed out (Grunwald et al., 1999; Klimesch, Doppelmayr, Schimke, & Ripper, 1997). One study reported that processing visuospatial and verbal tasks revealed a significant increase in theta power in the EEG at the end of processing (Gevins, Smith, McEvoy, & Yu, 1997). This suggested minimal working memory loads at the beginning of processing in these tasks and maximal working memory loads at the end of processing. Then researchers (Knecht, Kunesch, & Schnitzler, 1996; Roeder, Rosler, & Hennighausen, 1997) proposed that cognitive processing of haptic object recognition is a serial process that involves working memory. The theta power over frontal-central regions (Fp1, Fp2, F3, F7, F8, Fz, C3) increased during recall of haptic information (Grunwald et al., 1999). Furthermore, the theta power over several regions (F3, C3, Cz, C4, P3, Pz, P4, T5, T6, O2) increased during a haptic object recognition task towards the end (Grunwald et al., 2001).

2.2.2.3 Illusion of tactile feeling

A typical experimental method utilises combined tactile and visual information to induce participants to feel an alien limb as a part of their own body. Participants viewed a fake hand being stroked or vibrated while they experienced a similar stroking movement (Botvinick & Cohen, 1998; Pavani, Spence, & Driver, 2000). It is suggested that this illusion might reveal a three-way interaction between vision, touch and proprioception (sensing of muscle length, muscle force, and joint angle) (Botvinick & Cohen, 1998). A functional neuro-imaging study pointed out that the multi-sensory integration was processed in the premotor cortex (Ehrsson, Spence, & Passingham, 2004). From these findings, the function of the brain to identify our body from others objects is becoming understood (Botvinick, 2004).

2.2.2.4 Summary of cross-modal effect of touching

The findings of a cross-modal effect indicate that touching activities involve a three-way interaction between vision, touch and proprioception. The advanced cross-modal findings provide more information in an attempt to explain the touching effect during finger reading.

2.2.3 Factors affecting tactile acuity

2.2.3.1 Aging, gender and finger size

Aging was found to be negatively correlated with tactile acuity (Wickremaratchi & Llewelyn, 2006). Though children performed better than adults at two-point discrimination (Gellis & Pool, 1977), this result could be disregarded because two-point discrimination was criticized for failure to measure the limit of spatial resolution. The gap discrimination task was designed (J. C. Stevens & Patterson, 1995) to overcome this drawback and their results indicate that children and adults have similar spatial tactile acuity. Later, children were shown to significantly outperform young adults at gap discrimination (J. C. Stevens & Choo, 1996). Children may have better tactile discrimination than older and younger adults. A decrease in the density of receptors in the fingers was found over the course of adult life, presumably due to the dying of receptors. Especially within the age group of 50-59 years there is a marked decrease in receptors. One study showed that there was significantly higher tactile acuity of grating orientation discrimination in the younger group (the mean age was 27.6) compared to the older group (the mean age was 51.9) (Sathian, Zangaladze, Green, Vitek, & DeLong, 1997).

Another reason that was suggested was that children have a superior tactile acuity due to a higher density of receptors in the fingers because of their smaller finger size compared to adults. The concept is that the number of receptors remains constant over a period until the age of 50. The decrease in the density of receptors in the fingertips, such as Meissner's corpuscles, was found during the first two decades and this decreasing density of receptors is probably due to the increase in size of the finger with aging (Wooddruff-Pak, 1997).

Based on one anatomical finding (Dillon et al., 2001), tissue samples from index and ring fingers from 28 cadavers were collected and no difference between the total Meissner's corpuscles per finger in men and women was discovered. Instead, men usually have significantly larger finger size with a lower density of Meissner's corpuscles compared with women. This may account for the higher tactile sensitivity seen in women, because a bigger finger size of men yields a lower density of Meissner's corpuscles. This idea is supported by the fact that the women showed a superior tactile acuity in the GOT task (Goldreich & Kanics, 2003) and tactile recognition task (Vega-Bermudez et al., 1991). It is thus expected that finger size might be an important indicator of better relief acuity performance, since the GOT has a significantly positive relationship with relief recognition.

2.2.3.2 Aging and eccrine sweat glands

The elderly have been found to possess less active eccrine sweat glands (about 70%) in the digits and palms than young adults (Inoue, 1996), which might lead to less active finger motor preparation and movement. Finger motor preparation and movement might serve a functional role in tactile identification. This might be one of the factors explaining why the elderly have lower tactile acuity than young people.

2.2.3.3 Skin conformance

Skin conformance means that the ability of the skin is to conform to spatial details of surfaces of objects. This ability is assumed to play an important role in discriminating fine spatial characteristics and it has been found to account for 50% of variance in a measure of GOT (Vega-Bermudez & Johnson, 2004). Younger and older participants had the same skin conformance. This suggests the lower tactile acuity of older people is mainly due to the loss of tactile neural receptors.

2.2.3.4 Creative people with a certain hand skill

Results with similarly quick tactile adaptation have been obtained by professional pianists, who demonstrated superior tactile performance and learning as well (Ragert, Schmidt, Altenmuller, & Dinse, 2004). Pianists, generally, relate to creative people with a certain skilled touch, which in turn appears to show that people who have a certain hand skill might have better tactile sensitivity.

2.2.3.5 Blindness

Many results carry convincing evidence that blind people show better tactual acuity than normal sighted people (Goldreich & Kanics, 2003; Sathian, 2000; Van Boven et al., 2000). These results probably reflect the specificity of perceptual learning due to Braille-reading experience, the practice effect depending on the specifics of their tactual experience (Grant et al., 2000).

2.2.3.6 Practice

Practice effects might lead to better tactile acuity in the blind. Previous work has demonstrated that there is considerable perceptual learning using a dot pattern task, the threshold dropping by about 50% over a few sessions (Grant et al., 2000; Sathian & Zangaladze, 1998). The learning effect occurred in pattern recognition tasks, indicating an increase of 4 % in correct rate per hour under no feedback or training conditions (Vega-Bermudez et al., 1991).

2.2.3.7 Deprivation of light

One tactual study in the normal sighted suggests that tactual acuity could be enhanced by way of short term light deprivation for only 90 minutes in complete dark, indicating a rapid improvement of tactual acuity (Facchini & Aglioti, 2003). In addition, tactual acuity in normal sighted people is enhanced by means of being blindfolded for five days, yielding an increase in Braille character discrimination (Kauffman, Theoret, & Pascual-Leone, 2002).

2.2.3.8 Acute hand deafferentation

Applied acute deafferentation shows a rapid improvement in tactual acuity for the left hand during cutaneous anaesthesia of the right hand (Werhahn, Mortensen, Van Boven, Zeuner, & Cohen, 2002).

2.2.3.9 Visual-tactile interaction

Several of the studies show the additional requirement of viewing hands in order to enhance tactile acuity. Two-point discrimination was compared between conditions in which participants could not see the two-point pins, where participants saw their arm (Figure 2-10a), a magnified (x2.5) view of their arm (Figure 2-10b), a neutral object appearing at the location of their arm (Figure 2-10c), or darkness (Kennett, Taylor-Clarke, & Haggard, 2001). Tactile acuity was better when viewing the arm than when viewing darkness or a neutral object. Interestingly, seeing more visual detail with a magnifying lens has the best significantly improved tactile acuity in contrast to the other three conditions.

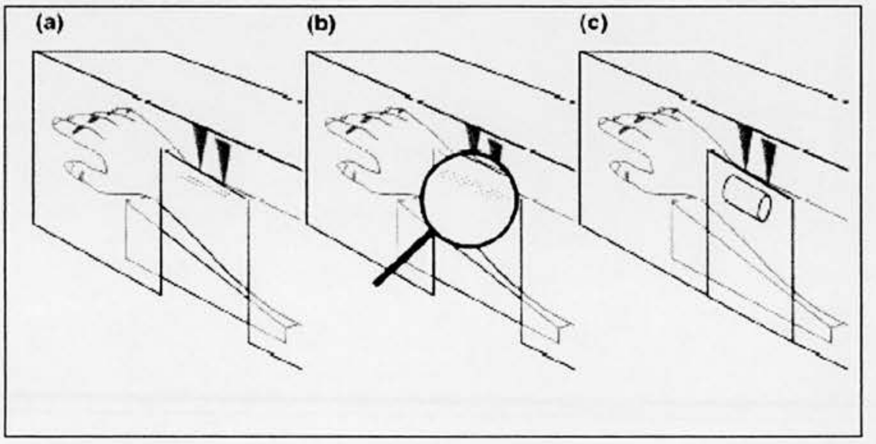


Figure 2-10. The two-point discrimination conditions (from Kennett et al., 2001)

A similar result of improved tactile discrimination was found when viewing the fingertip, compared to viewing the neutral object (Taylor-Clarke, Kennett, & Haggard, 2004), as well as an observed enhancement in haptic spatial perception when informative vision was possible (Newport, Rabb, & Jackson, 2002).

2.2.3.10 Visual imagery

Visual imagery has been implicated in the normal tactual perception of certain object properties in three studies. In these studies, the participants were asked to use visual imagery while touching, which is very similar to what happens in the finger-reading process. In one study (Klatzky, Lederman, & Reed, 1987), the participants were asked to sort a set of objects by touching them unseen. Participants who were told to sort according to the visual imagery of the objects tended to emphasise shape and size, while other subjects, who were not given any instruction about visual images, sorted mainly by virtue of texture and hardness. The features that are salient in visual imagery are those that might be termed "macrogeometric", while those that are salient in the tactile feel of objects in texture might be termed "microgeometric" (Sathian & Zangaladze, 2002). The visual cortex was involved in tactual discrimination of orientation but not in spatial frequency (Sathian & Zangaladze, 2002; Sathian et al., 1997), which indicates that visual imagery has influence on tactual perception and in processing macrogeometric features.

2.2.3.11 Stochastic resonance effects

'Stochastic resonance effects' means that a certain type of noise enhances the detection of a weak signal (Wiesenfeld & Moss, 1995). A certain type of noise below threshold was successfully applied to assist in detecting a tactile stimulus under threshold (Collins, Imhoff, & Grigg, 1996), as well as enhancing vision (Simonotto et al., 1997) and hearing (Long, Shao, Zhang, & Qin, 2004). This effect might boost the sensory receptors and their sensory afferents or (and) the brain's sensory cortices (Yamamoto et al., 2002).

2.2.3.12 Summary of factors affecting tactile acuity

The author suggests that the effects of finger size, aging, gender and practice on tactile acuity are worth investigating in this thesis. One may predict that people with a smaller finger size will have better tactile performance than those with a bigger finger size in terms of pattern recognition. Women will perform better in pattern recognition than men due to men having a larger finger size.

Children may have superior tactile acuity, due to a smaller finger size with a higher density of receptors in the fingers (the density of receptors remains constant over a long part of the lifetime). This might suggest that children could perform better in relief recognition tasks. In fact, there have not been any studies of relief recognition using children so far. It is not certain if children could perform well in relief recognition of 0.5 mm or below in elevation. We do not know how sensitively children can perform in tactile tasks. Children will be assessed at the limit of relief recognition in this thesis. This is one of the major interests in this thesis. The elderly will not be included as participants in this thesis because of their poor tactile performance.

The relationship of skin conformance and tactile acuity will not be explored because investigating this needs very expensive apparatus, although skin conformance gives a fine measure of tactile acuity. Special groups of people, such as the blind or people with a certain hand skill, will be excluded although they have superior tactile acuity. But their results imply that relevant long-term touching practice might be relevant to superior tactile acuity, so, in turn, the point about touching practice will be taken into account in this thesis. The author will collect similar information from participants through questions, such as 'how many hours do you use a keyboard per day?', 'how good do you think your touch sensitivity is?' and 'do you have a job or hobby involving touch sensitivity?'

Tactile perception has a special role in body representation. Viewing position was found to influence tactile perception, which suggests that our primary somatosensory cortex is modulated by body representation. The perception of body representation is related to visual input of body position and proprioception (Botvinick, 2004). Understood in this way, it would be interesting to investigate the manipulation of body representation in the finger-reading effect. The author will not investigate this issue here, but will minimise the effect of this variable on tactile acuity. A good strategy proposes that participants should not be able to see their hands, including their fingers during touching tasks.

Temperature, darkness and a patterned type of noise might have some impact on tactile acuity. These factors should be controlled while conducting tactile experiments in later Chapters. Temperature should be controlled in a comfortable range, normal light condition is suggested and any noise should be eliminated, including any possible patterned sound. The effect of enhanced tactile acuity caused by practice should be attended to and measured in Chapter 4.

The effect of visual imagery on tactile relief acuity will not be explored in Chapter 4. The reason is the experiment of assessing the limits of tactile relief recognition in Chapter 4 can be regarded as a control experiment comparing the later finger-reading training experiments in Chapters 5 and 6, since the former experiment will not have any instruction and feedback.

2.3 Summary

The finger-reading effect has never been replicated and supported. Some of the participants might have figured out how to cheat. This possibility is most disappointing but it needs to be resolved. Importantly, it is hoped to rule out fraud in future studies. To solve these problems, the answer is simply to run finger-reading experiments under well-controlled conditions. The author suggests adopting the paradigm originally developed by Si-Chen Lee to further explore this finger-reading effect.

The finger-reading procedures are developed from Chinese culture. One might ask whether it can be applied in Western culture. Needless to say, no studies of this issue have been undertaken. To answer this question, the author would like to make the initial assumption that, if there is such a thing as ESP, it would be a universal possibility and not culture-specific. It is a good strategy that we find out what happens when finger-reading studies are conducted in Western society.

Although Lee's results reveal that adults might not be able to benefit from the finger-reading training, this point needs to be further defined since it has not been tested by other researchers. In this thesis, only children will be included. Indeed, it will be a good strategy that the finger-reading training with children can be studied first since they might have more potential to obtain ESP than groups of any other ages. If the finger-reading effect in children is valid, further studies can be carried out in the future.

In connection with the possible role of visual imagery in the finger-reading effect, it seems that at first the participants practised visual imagery and then participants visualised the target, acting as a vivid vision reported by the participants. Many questions arise from this effect. Did participants see the same vivid vision since few among participants described this vivid vision clearly? What is the formation process of this vivid vision? Is this visual experience in the touching effect like visual imagery or an illusion or a hallucination? A good strategy is to understand the basic properties of this vivid vision, such as the subjective formation reported by participants and if there is a common experience of this vivid vision.

This Chapter includes an overview of studies that have explored tactile acuity. Special emphasis is put on describing the function of tactile receptors, clinical measures of tactile acuity, factors affecting tactile acuity and cross-modal effects of touching. As for the factors affecting tactile acuity, such as aging, gender, finger size, eccrine sweat glands, skin conformance, blindness, practice, light deprivation, hand skills, acute hand deafferentation, visual-tactile interaction and stochastic resonance effect, the factors of aging, gender, finger size, temperature, light condition, patterned noise will be taken into consideration while conducting the later experiments.

Before turning to the experiments that will be conducted later for this thesis, the use of the information provided in this Chapter about methods and hypotheses will be addressed. Most importantly, the value of tactile relief recognition between 0.49 and zero mm in elevation will be determined in Chapter 4. From the point of view of normal psychology and the study of perception, this study is fundamental and important since it will contribute not only an important understanding of the tactile mechanisms involved in such measures, but may also have practical implications for real-life relief tasks such as Braille-reading.

Chapter 3. Methodological considerations

The main objective of this thesis is to make improvements on current finger-reading training paradigms and then to use those paradigms to test whether untrained and trained people have a finger-reading ability. To achieve this objective, the researcher must first give consideration to the question of safeguarding against fraud, since claims of deception are prevalent in the parapsychological literature and so the researcher must ensure that training and testing procedures are appropriately guarded against fraudulent behaviours.

The finger-reading training procedures developed by Si-Chen Lee appeared to yield exceptional tactile recognition or ESP perception via the fingertips of children. These results may be unreliable due to a lack of rigorous controls to rule out possible fraud. Thus, claims about finger-reading ability cannot yet be considered to be established. This chapter will then begin by considering the main features of current finger-training paradigms. It will conclude by giving methodological consideration to the issue of prevention of fraud.

This Chapter then goes on to consider methodological issues, which point out the deficiency of well-controlled conditions in all the finger-reading studies reviewed. This leads to a conclusion that fraud has not been entirely ruled out -- suggesting unreliable finger-reading results. In addition, this finger-reading effect has never been replicated. It is thus not safe to assume that exceptional abilities were in fact successfully measured. Finger-reading needs to be further explored under stringent conditions, especially in children. The detailed suggestions serve to modify the finger-reading procedure in terms of its safeguards. Finger-reading will be further explored under stringent conditions. Following this idea, pilot trials are considered which would develop techniques empirically and assess controls on the finger-reading training processes. A well-developed finger-reading training paradigm was established in this Chapter[3]. Considerations in conducting the finger-reading studies, including general and ethical considerations, were discussed.

3.1 Discussion of experimental controls in general

While conducting ESP experiments, "the goal of the experimenters is the complete

[3] An experienced parapsychologist, my late supervisor, Professor Robert L. Morris, was involved in the modifications to this training paradigm. The main body of this Chapter has been published in the Journal of Parapsychology (Shiah, 2005) (Appendix 2). Due to the publication lag, this paper has been actually published in March 2007.

exclusion all possible sensory cues, which includes assuming the dishonesty of the subject" (J. B. Rhine, 1938). Possible sensory cues lead to other unwanted explanations -- such as fraud -- for ESP phenomena. To solve this problem, the long-standing issue of psychic fraud must be considered (C. C. French, 2005; Hansen, 1990; Hyman, 1985; Morris, 1986; Palmer, 1986, 2003; J. B. Rhine, 1974). Two major topics will be considered regarding psychic fraud in this Chapter. The first is fraud which might be caused by participants or experimenters. The issue of dealing with experimenters' deliberate "cheating" was not included. Even in mainstream science, the editors in the prestigious journal, Science, admitted that they can only decide a paper is worth publishing other than by detecting flaws in terms of experimenters' "cheating" (Couzin, 2006). Undeniably, experimenters can deliberately cheat in a variety of ways and this is almost impossible to be ruled out.

The other important matter is fraud control. Poor and inappropriate controls will increase the opportunities for participants to cheat. Although the issue of deliberate experimenter cheating was excluded, experimenters might unconsciously deceive because of weak fraud controls. For this reason, it is a good strategy to take this point into consideration in the design of well-developed safeguards.

Parapsychologists have been working on the idea of how to construct perfect safeguards against possible fraud. The development of the *ganzfeld* technique provides a good model for finger-reading training procedures. The *ganzfeld* technique is regarded as providing a good research tool to provide replicable evidence of *psi* ability (Utts, 1991). This is because much effort has been made to modify the procedure and provide safeguards to meet strict standards (Goulding, Westerlund, Parker, & Wackermann, 2004). Thanks to the *ganzfeld* technique developments of the 1970s (W. G. Braud et al., 1975; Honorton & Harper, 1974; Parker, 1975), the procedure is now highly shielded against sensory leakage (Morris et al., 2003). The technique has been tested and modified in over one hundred studies over the last three decades (Palmer, 2003; Parker, 2003). ("Sensory leakage" occurs when participants obtain information sensorily rather than extrasensorily (Irwin, 2004).) From the *ganzfeld* technique example, it is also revealed that well-controlled finger-reading procedures will take lots of time and effort.

A mind and matter interaction model proposed by Morris (1999) provides a general guideline for building effective safeguards. A methodological quality rating of between 0 and 16 developed to evaluate clairvoyant studies published from 1935-1997 was used (Steinkamp, Milton, & Morris, 1998). This study can serve as a good checklist for examining ESP experimental design. Likewise, the ganzfeld technique is highly shielded against sensory cues and is now regarded as providing a good research tool to provide replicable evidence of psi ability. Following these examples, the author suggests that safeguards should be considered, such as pre-specification of objectives, condition of invalid trials and hypotheses, pilot study before formal experiment, recruiting unselected participants, randomisation, effective barriers and interpretation of the results.

3.1.1 The specific problem of fraud in ESP studies

Many psychical abilities have been the subject of interest of academic society, such as parapsychology. Nevertheless, some claims to psi abilities were found to involve cheating. For instance, in 1988, five scientists and one member of staff of the Executive Council of the Committee for the Scientific Investigation of Claims of the Paranormal went to Mainland China to do a preliminary test of several kinds of ESP abilities, such as a psychic woman claiming to be able to diagnose illness by seeing into a person's body, a Qigong master claiming to be able to transmit his external Qi to a person for some healing purpose and children claiming to have clairvoyance by touching. They found no evidence of any psychical ability of the psychic woman and Qigong master. Even the positive results with the children were found to contain clear evidence of cheating (Kurtz et al., 1991).

Similarly, as seen in a later section, many participants who claimed to possess finger-reading ability have been found to use deception -- as well as there being many deceptive participants found in the past (Hansen, 1990; Morris, 1986). This fact is considered as a serious problem that can damage the reputation of parapsychology and its progress (Palmer, 1988). It truly raises an important issue, the problem of fraud in psychical research. For this reason, the issues of how fraud will happen, how fraud will be prevented in advance and how fraud will be detected during performing will be stated. Importantly, to sum up, a specific solution to prevent fraud will be reported in the later section on methodological safeguards in finger-reading studies. This Chapter will deal with each of these in turn.

3.1.1.1 How will fraud happen?

3.1.1.1.1 Motivation

First of all, motivation needs to be investigated. Several possible motivations are validating one's psychical ability, obtaining financial rewards, increasing attention from a variety of observers, increasing personal power or, sometimes, increasing self-esteem through fooling scientists (R. Wiseman & Morris, 1995). Even worse, researchers themselves might commit fraud to satisfy their needs; for example, they may seek academic reputation or financial rewards and so forth. This can scarcely be detected or prevented.

The fact is that many adults have attempted psychic cheating (Hansen, 1990, 1992; Hyman, 1985; Morris, 1986), as well as many children (Nicol, 1985). It is a good strategy that researchers should assume the participant has a certain degree of motivation to undertake cheating. Adopting this premise, strict fraud controls should be implemented while conducting ESP experiments.

3.1.1.1.2 Trickery

Apparently psychical powers might be demonstrated using standard conjuring techniques (Hansen, 1992; R. Wiseman & Morris, 1995). To become really proficient at conjuring is not achieved in a day (Lewis, 1990), but a greater appreciation can be had with less effort since a more fruitful discussion with professional magicians has been suggested. The book "Magic in Theory" (Lamont & Wiseman, 1999) aimed at presenting the theoretical elements of conjuring as understood by competent and experienced conjurors. This book helps parapsychologists investigating psychical claims to be more aware of deceptive magic performance. Methodology strategies, such as controlling the selection of information, marks, glimpses, receiving secret codes from another person and switching the original target, might be used to produce distortion of ESP abilities. One useful method to evaluate the likelihood of trickery is to survey a participant's history (Hansen, 1990), such as any psychic claims being made before or training in magic.

3.1.1.1.3 Weak safeguards

Weak safeguards will increase the likelihood of attempting fraud and they are the most important issue to be dealt with. A general guideline for designing effective safeguards will be stated later. The author will outline strategies to implement controls.

3.1.1.2 How will fraud be prevented in advance?

A model was proposed to describe how factors should affect an experimenter's assessment of the likelihood that mind and matter interactions (MMI) have occurred (Figure 3-1) (Morris, 1999). The model provides general guidelines for building effective safeguards.

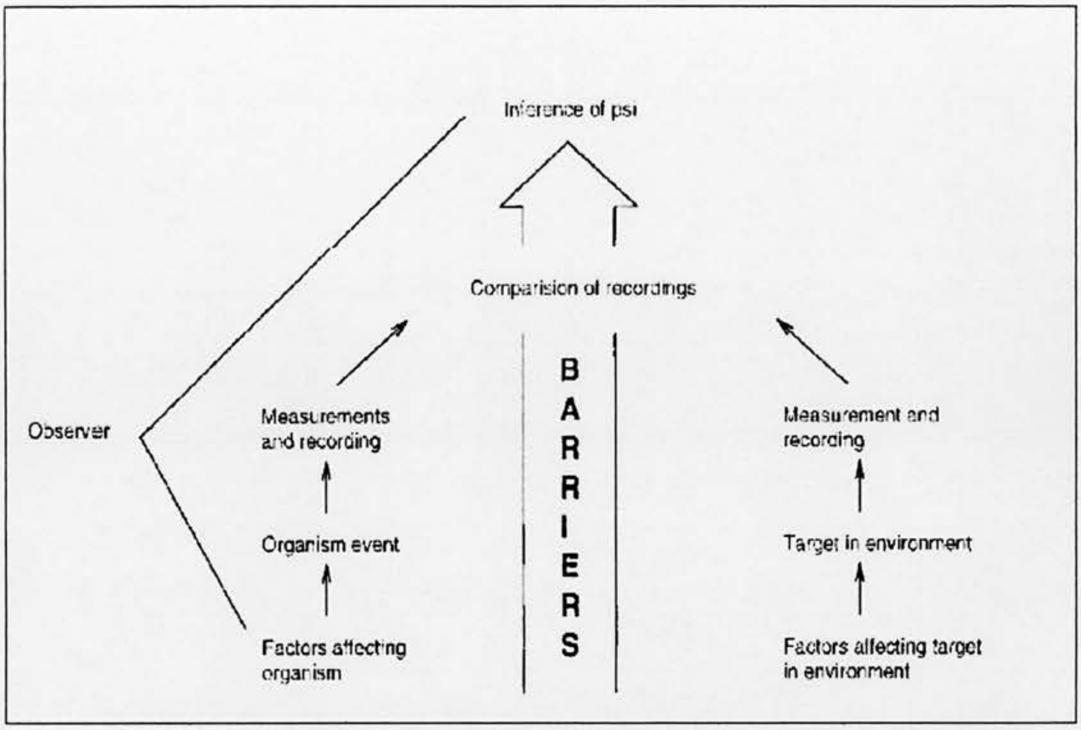


Figure 3-1. A model describing how factors affect an observer's assessment of the likelihood that MMI has occurred (from Morris, 1999)

In judging whether or not MMI has happened, the observer usually is the researcher. If the participant is being evaluated for ESP, then we need to see if the participant has received input from an external event. The target is that with which the participant appears to be interacting without using presently understood means. Barriers prevent all presently understood means of interaction, including distance, time, or shielding.

Briefly, this model could be used as a framework for preventing deception in advance. First, observers, usually the researchers, need to know what to observe and when and where to observe. A pilot study should be run before any formal experiment. This pilot study should be designed as an initial assessment for the following formal experiments and will help the observer to find out what to observe and when and where to observe.

Secondly, barriers are expected to prevent cheating and unwanted explanations which will be mentioned more later. An effective barrier has many elements (R. Wiseman & Morris, 1995). The researcher should be skilled at countering psychic fraud through consulting with magicians, technical specialists and reviewing conjuring/pseudopsychic literature. Potential claimants could be informed that experts, such as magicians, might be consulted to help design or run studies. Participants should receive very little reward and will not receive any certificate from the researcher. During the pilot or formal study, the researcher needs to develop controls to minimise the possibility of normal explanations, such as randomly selecting targets, and preventing normal channels of communication between the target and participants. Finally, the measurement and recording of the target event needs to be objective to eliminate possibilities of recording errors and data manipulation, as will be fully spelled out later.

3.1.1.3 Safeguards

Based on the idea of the MMI model above, safeguards must ensure that the experimental design rules out unwanted interpretations with respect to poor observation, sensory leakage and fraud (Milton, 1996; Morris, 1999, 2001; Steinkamp et al., 1998). Many efforts have been made by parapsychologists to develop a strict methodology for experimental parapsychology to test ESP in a controlled laboratory situation and statistical methods (W. Braud, 1999; Brier, 1999; J. E. Kennedy, 2004; Lamont & Wiseman, 1999; Milton, 1996; Morris, 1987, 1999, 2001; Palmer, 1986; Stokes, 2002; R. Wiseman & Morris, 1995). Different researchers have different concerns and requirements for safeguards in their studies. This is a complicated problem. The specific procedure for different research cannot be described in this thesis. For this reason, in this section, the author will focus more on general safeguards for the methodology in finger-reading studies:

3.1.1.3.1 Pre-specification

The objectives need to be clearly identified so that the experimental design could then meet the objectives. Hypotheses, experimental procedures and planned statistical analyses should be specified before conducting experiments. Experimenters have the right to declare a trial invalid. The conditions for declaring a trial invalid should be specified before experiments.

3.1.1.3.2 Pilot and formal study

A pilot study is required before a formal experiment, not only to maximise the possibility for participants to perform their psi ability but also to assess the controls that will be used in the formal experiment. The design of the pilot and formal experiments should be fully described. The report should mention the controls used against fraud.

3.1.1.3.3 Randomisation

Weak randomisation procedures are considered a serious problem (Bierman, Broughton, & Berger, 1998; Brugger & Taylor, 2003; Diaconis, 1978; Ertel, 2005), therefore, a target should be randomly selected from the target pools. The type of randomisation needs to be pre-specified in writing, such as the details of the procedure, target selection with or without replacement, the model name of the computer, the full reference of the name of random generator and its maker's number.

3.1.1.3.4 Unselected participants

The major reason for employing unselected participants is that the results obtained from them can be widely generalized to the population. Practically, unselected participants are more available. Furthermore, it really increases the risk of cheating by only investigating a single participant (Hansen, 1990).

3.1.1.3.5 Barriers: sensory shielding

Important suggestions for sensory shielding are as follows:

3.1.1.3.5.1 Participants and experimenters/co-experimenter

Experimenters/co-experimenters and participants should not know targets before conducting experiments -- by using the double blind method. Information about recruiting participants, the background of the experimenter/co-experimenters, a description of any suspicious behaviour of participants during experiments and the background of participants, including any claims of psi abilities or magical experience, all need to be specified.

Co-experimenters who prepare samples should not take part in experiments or have any relationship with participants. Participants will not be allowed access to radio communication or mobile phones during experiments. If participants drop out of a study, the reason should be reported and their data should still be presented.

3.1.1.3.5.2 Targets, procedure and recording of participants' responses

Two kinds of ESP experimental design are usually used. The first one is restricted choice, evaluating the ability to be a good chooser from among known alternatives. The second one is free response, evaluating the ability to respond to a qualitatively rich random target chosen from picture, film or complex object pools. This one is more difficult and complex than the method of restricted choice.

Procedure should be described in detail. Experimenters should keep a detailed record of participants' responses. Security to prevent cheating (such as accessing target pools, peeking at targets, changing experimental records and replacing targets) should be provided. Targets need to be prepared alone in an isolated room by another experimenter/co-experimenter who will not join in the experiments. Details of the materials, how targets are kept secure between being taken out of storage and being used in experiments must be reported. Participants should not handle any target container or targets that were used previously, because they might receive target feedback from natural or deliberately-made marks or imperfections.

If during a trial, the trial is abandoned, this decision should be written down. Participants should report their final responses before any feedback is given. Participants should not subsequently be allowed to change their responses.

3.1.1.3.5.3 Room and shielding tools

The details of experimental rooms and shielding tools should be noted. The room must be screened or guarded against peeking. Windows, mirrors and poked holes will allow peeking. Researchers should make a balance between providing security and a comfortable environment.

3.1.1.3.6 Interpretation of the results

Hits, participant's responses and records should be double-checked by different researchers. Adequate statistical method will be used to determine whether or not the experiment's outcome exceeds chance expectation and the results will thus be correctly interpreted. In addition, other parapsychologists or researchers not involved in the study should be asked to assess the report in terms of its methodology and result. The detailed background of consultants, such as names and qualification, should be described.

3.1.1.4 How will fraud be detected during performance?

Deception takes place as a complex cognitive process in humans. So far detection of deception can be achieved in two different ways. One way is via observation. Response time might be as an important indicator to deception. It is suggested that extended response time is an indicator of deception (Walczyk, Roper, Seemann, & Humphrey, 2003). It is logical to infer that a participant needs more time to attempt deceit when carrying out a delicate trick.

According to a very comprehensive review of 116 research reports on deception (DePaulo et al., 2003), there were reported 158 verbal and behavioural clues to deception. The clues were in five categories: 'liars are less forthcoming than truth tellers'; 'liars tell less compelling tales than truth tellers', 'liars are less positive and pleasant than truth tellers'; 'liars are more tense than truth tellers' and 'lies include fewer ordinary imperfections and unusual contents than do truths'. These clues could be very useful in telling when participants tend to engage in deception.

A polygraph is most commonly used, although recently the British Psychological Society has raised questions about their effectiveness (Bull et al., 2004). Polygraphic measures of respiration, pulse, relative blood pressure and electrodermal response, are widely used to detect deception. The polygraph is not convenient since it needs uncomfortable physical contact with participants. One new effective way developed without physical contact and skilled staff to detect deception is called the thermal-imaging technique. It has been claimed that a thermal-imaging machine with high-definition thermal imaging of the face detected deception because it enabled detection of rapid changes in regional facial blood flow and performed an automated analysis of these changes (Pavlidis, Eberhardt, & Levine, 2002). In their study, Pavlidis et al. asked volunteers to commit a mock crime and then to testify their innocence under experimental conditions at the US Department of Defense Polygraph Institute (DoDPI). Participants were randomly assigned to a criminal condition and then they asserted their innocence of the "crime". Control participants had no knowledge of the crime or of the crime scene. The thermal imaging system correctly categorized 83% of these participants: 75% of the guilty participants were correctly identified as guilty and 90% of the innocent individuals were correctly categorized as innocent. Polygraphic testing performed by experts at DoDPI on the same participants, correctly categorized 70% of the participants: 75% of the guilty participants were correctly identified as guilty and 67% of the innocent individuals were correctly identified as innocent.

P300 amplitude has been used to explore deception (Rosenfeld, Rao, Soskins, & Miller, 2003). In this study, participants were shown dates and asked question about them. Participants responded verbally yes or no, but dishonestly on about 50% of the trials and truthfully on the other 50%. P300 amplitude was reduced in dishonest trials, unlike in honest trials. Transcranial magnetic stimulation of the motor cortex in conjunction with a constrained question was used and the answer protocol for the first time showed increased cortical excitability when generating deceptive responses, in contrast with truthful responses (Y.-L. Lo, Fook-Chong, & Tan, 2003). A fMRI study revealed different types of lies could arise from different neural systems (Ganis, Kosslyn, Stose, Thompson, & Yurgelun-Todd, 2001).

Lately, it was reported that Dr. Jennifer Vendemia is developing a very effective method of detecting whether someone is lying by monitoring brainwaves (Summers, 2005, January 14). It is claimed that the system has an accuracy of between 94% and 100%. Apparently, this is the best lying test. This system involves placing 128 electrodes on the participants' face and scalp to measure brainwaves when they respond the questions. Use of neuroimaging to detect deception should be possible in the future. However, it is said the system has a long way to go before it replaces the currently popular polygraph. Overall, modern lie detectors are far from 100% accuracy and so they are not generally considered to be reliable means for detecting deception.

3.1.2 Summary

Before the experiment, researchers should inspect participants' motivation and any background of trickery, including any claimed psychical abilities and experience of magic. Assuming that participants might attempt cheating, major efforts should be made in advance to eliminate possible fraud. Based on the MMI model, safeguards should contain pre-specifications, a pilot and a formal study, unselected participants, effective barriers and unbiased interpretation of the results.

Hansen (1990) pointed out that human observation is very unreliable, especially in failing to perceive tricks. To work this shortcoming out, several strategies can be alternatively suggested. Firstly, sometimes parapsychologists like to work with magicians because of their specialized knowledge. A magician will greatly help to detect deception on the scene during the testing of psychical abilities or when examining the safeguards. Note that fraud cannot be entirely eliminated in ESP experimental designs even with help from magicians (Hansen, 1990). Most importantly, the best strategy is to establish well-developed safeguards against possible fraud before conducting ESP experiments.

Taken together, obviously, no ESP experimental designs can provide perfect safeguards against fraud. Worse, experimenters themselves may attempt deceit. How do we deal with this problem? In normal science, actually, studies are hardly ever accepted until they are replicated. The possible best way to rule out fraud -- including the mentioned limitation of ESP experimental designs above -- is to have replication by different researchers.

3.2 Critique of finger reading studies reviewed in Chapters 1 and 2 in the light of these methodological issues

3.2.1 Methodological problems in the Eastern studies

No satisfactory explanations of the phenomena were given, nor were the procedures described in sufficient detail in published reports done in Mainland China. Thus, the whole process cannot be evaluated. It is not clear whether the researchers ruled out fraudulent techniques such as those used in performance magic. For example, in 1981, children were caught peeking by scientists during finger-reading tests (M. Gardner, 1996).

Before examining Lee's finger-reading training paradigm, we should take a look at his training procedures. Lee's training procedures have never been mentioned in detail in any published journal. Most of the procedures depend on the first author's observations during the time when he worked with Si-Chen Lee, who helped to clarify some of the described procedures.

Although the training procedures had been developed over ten years, they still need to be evaluated scientifically in order to rule out possible fraud and biases as well as to establish a well-controlled procedure for conducting later research. A complaint of inadequate controls will be discussed later.

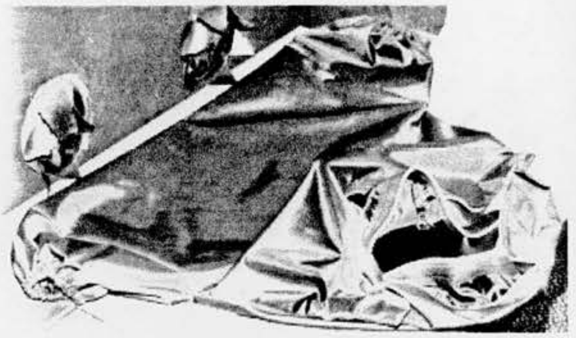
3.2.1.1 Lee's design and procedures

3.2.1.1.1 Material for characters

There was usually a 5cm x 8 cm rectangular piece of paper. In the middle of the paper was a two-digit number varying in four different colours, such as black, green, blue or red, printed by an ink printer. There were two-digit numbers from 11 to 99. But the confounding numbers, "double chance numbers", such as 16 and 91, 19 and 61, 18 and 81, 66 and 99, 69 and 96, 68 and 89, 86 and 98, were excluded. There were 75 numbers used in all. A certain number of samples were always produced by a research assistant who did not participate in the finger-reading training processes. They were folded twice and all put into a big envelope.

3.2.1.1.2 Barrier (black bag) (Figure 3-2)

This is normally used for handling or changing photographic negatives (double-lined changing bag, 43cm x 40.5cm, Tecnodia Co., Ltd. Japan). Two cuffs are snugly fitted around the participant's forearms and the bag has two layers, each with its own zipper. Hardly any light could enter the bag, as was empirically shown by a light detector. The participant could move and feel around freely within the bag. The purpose of the bag was to prevent the participants, experimenters and co-experimenters from seeing or peeking at the targets.



3-2a. The bag has two layers, each with its own zipper

3-2b. The participant's two hands are fitted into the bag

Figure 3-2. The experimental bag

3.2.1.1.3 Recruiting

The recruitment advertisement included an introduction to finger reading, the purpose of the training and a consent form. Children aged between seven and thirteen were recruited. There was no special policy for selecting participants.

3.2.1.1.4 Procedures

3.2.1.1.4.1 Warm-up training before the finger-reading training

The training period did not exceed two hours a day. There was a 30-minute break during each day of training, during which participants had drinks or snacks. Participants were first required to watch a 30-minute videotape describing this "touch" phenomenon, such as how to identify the target. The purpose was to activate the participant's interest and motivation in the touch task.

The training process began with the warm-up training. First of all, the experimenter turned the light off. Participants were required to sit and close their eyes, and breathed deeply with a calm and peaceful mind for at least ten minutes. Then participants were required to practice image-making. The light had been put back on. The experimenter showed a red apple (or other objects) to the participants who were asked to look at the apple very carefully and to remember every detail of it. Then they closed their eyes to visualise the apple exactly as they perceived it. Next, they visualised the apple by changing its colour three or four different times, i.e., through green, blue and black. Eventually, the experimenter asked the participants to raise their hands and to focus their minds on their fingertips.

3.2.1.1.4.2 Training procedure -- directly touching a two-digit number

The experimenter usually randomly drew ten samples from the big envelope and put them on the co-experimenter's chair. Then, the co-experimenter clenched one sample into his or her fist and put it in the bag, and then closed the zippers. Participants did not see the target during this process. Next, participants put their hands into the two sleeves of the black bag and the sleeves were tied up. Participants were allowed to open the folded samples to use their fingers to scan targets. During the finger-reading training procedures, the participants were required to focus on touch and to imagine that they could see the numbers while touching. There were no time restrictions and participants were free to use whatever scanning pressure and speed they chose. They removed their hands to write down the answer whenever they told the co-experimenter what they saw, and the co-experimenter recorded their response too. They took their hands out of the black bag after they told the co-experimenter their final response. In the meantime, the co-experimenter recorded the participant's response and response time.

After the participant finished the trial, the co-experimenter took out the training item from the black bag and showed the number to the participant. Thus participants received feedback and the co-experimenter recorded if the participant's response was correct. Usually, children would attempt 20 items in one session, lasting two hours.

3.2.1.1.4.3 Training Procedure -- directly touching a complex target (a Chinese character)

Participants who had a statistically significant performance level were invited to attend this further session. Most of these reported experiencing a subjective visual experience when recognising the targets, and many of them described seeing a transparent or opaque screen in their mind. This training procedure was the same as the training procedure of directly touching a target (a two-digit number), but the stimulus was now a Chinese character. The purpose of the training was to help children to have the superior imagery function which tends to be associated with experiencing an opaque visual screen. An opaque screen occasionally occurred in this training session. This might account for the better ability to correctly identify targets.

3.2.1.1.4.4 Testing procedure

In Lee's testing procedure, the stimuli were drawn on a 5cm × 10cm or 3cm × 10cm rectangular piece of white paper (Lee, 1998; Lee et al., 2000). Written on the paper was a Chinese character, an English word, a symbol or mathematical formula - this was written in the middle of paper in four different colours of ink, such as black, green, blue or red. More than 50 samples were prepared for each testing session. The research assistant chose the target stimuli randomly. The testing procedure was the same as the training procedure. Computer software was used to produce testing samples randomly (Lee, 2002; Lee et al., 2004). Several co-experimenters carefully watched the participant. Sometimes feedback was given to participants, while sometimes not.

3.2.1.2 Inadequate controls in Lee's procedures

3.2.1.2.1 Randomisation problem

A target should be selected randomly from target pools. The experimenter randomly drew several samples from the envelope (samples pool) and gave them to each co-experimenter. Plainly, this randomisation is inadequate.

3.2.1.2.2 Sensory leakage problem

Usually, one co-experimenter worked with two participants, or sometimes three participants. The co-experimenter could not carefully observe each participant's responses and behaviour.

The experimenter put samples on the co-experimenter's chair and the participants cannot see the samples. Although the sample, a small piece of paper, was folded twice to prevent seeing or peeking, a remote possibility existed that the experimenter or co-experimenters might see the mark from the outside.

The possibility that a target was replaced by a different one brought by participants is not excluded since no any actions to prevent this fraud have been taken.

The production of stimuli was not standardized in both procedures. Detailed information on how targets were prepared was not given. A tactile cue might be present due to different printing quality, especially in written samples. The procedures had not been examined by an expert in detecting fraud, so they may be open to cheating.

3.2.1.2.3 Participants and recording problems

Some factors that might affect tactile learning results were not excluded, such as participants who have a history of nerve or brain injury, finger trauma, or learning disability (including dyslexia), diabetes (because of associated peripheral neuropathy) and callouses on their finger tips (Goldreich & Kanics, 2003; Vega-Bermudez & Johnson, 2004).

Although over two hundred children have taken part in Lee's finger-reading training, their psychological traits and demographical background have not been studied. Such information might provide some useful explanations for this touch effect. After discovering which variables best predict the finger-reading effect, we could be in a position to discuss which assumptions or theories are closely related to explaining the phenomena, such as they are.

It is not clear if records of participants were double-checked by at least two different researchers/co-experimenters to avoid calculation error. Only individual scoring was analysed and not all the participants' trials were reported. All the trials for each participant were not clearly noted, as well as the method of analysis.

3.2.2 Methodological problems in the West

Likewise, Western finger-reading studies did not provide fully detailed information of randomisation procedures. They exhibit the same problems with participants and recording as described above. Sensory leakage is also a serious problem. In the Zavala studies, the research assistant prepared the samples involved in testing, although the experimenter was blind to the targets. It is not clear if the experimenter knew the target since the experimenter seemed to be able to see the targets if he or she wanted to look at them during the experiment.

Blindfolds have been found to provide only a rather weak control (M. Gardner, 1996; Hansen, 1990). Wearing a pair of blindfolds was used in Novomeysky's, Romans's and Zavala's studies; but this still provided only a weak safeguard against cheating, because it was possible for blindfolded people to see down through tiny openings made by muscular contortions or eye twitching. For this reason, it is not clear that their investigation ruled out cheating.

Claims that the finger-reading studies lacked sufficiently tight controls to rule out trickery were often reported - with peeking being an especially common problem. According to Gardner's report (M. Gardner, 1996), one 13 year-old boy in a 1937 study claimed that he could name playing cards without seeing them. J. B. Rhine, the famous parapsychologist at Duke University, tested this boy with opaque goggles and found him to be cheating by peeking over the bridge of his nose. In 1962, a 22 year-old Russian epileptic patient claimed to be able read while blindfolded, but she, too, was caught cheating by scientists. Also, in another study (Zubin, 1965), a 15 year-old girl claiming to have this kind of ability was tested. She wore a blindfold taped to her face around its edge and was found to have tensed the muscles in the areas of her blindfold to cause a very tiny opening allowing peeking down the side of the nose.

3.2.3 Common problems and limits of previous studies

3.2.3.1 Methodological problems

Methodological issues are a very serious problem in all finger-reading studies. In addition to the described problems, none of the reviewed studies provided fully detailed information about its safeguards. Measures to prevent cheating, such as possible access to target pools, changing experimental records and replacing targets, should be implemented. Details of the materials and how targets are kept secure between being taken out of storage and being used in experiments must be noted. Clearly, bad methodological design has been a major problem in all finger-reading studies. Still worse, some of the participants have figured out how to cheat.

3.2.3.2 Tactile cues

As for the printing quality, we could accurately identify touch recognition in terms of about three levels of intensity (Geldard, 1960). We can detect a very small difference of particle sizes with thresholds between 0.0024 and 0.0033 mm and the difference of ridge height thresholds was between 0.00095 and 0.002 mm (Miyaoka et al., 1990). Different printed colours might cause different levels of touch intensity, providing a tactile cue to detect different colours, especially when the participants only had to discriminate two colours on the same trial in Novomeysky's study. The details of how the samples were obtained were not fully noted in all previous finger-reading studies. In this case, the possibility of tactile cues cannot be excluded.

3.2.3.3 Replication problem

Parapsychologists have carried out a large number of studies examining the possible existence of ESP ability. A good example from parapsychology would give a very helpful guideline to carry out replications of the finger-reading training processes. For instance, the problem of replication of ganzfeld procedure has been largely discussed using meta-analysis (Bem & Honorton, 1994; Bem et al., 2001; Hyman & Honorton, 1986; Milton & Wiseman, 1999, 2001; Palmer, 2003; Storm & Ertel, 2001). Over one hundred ganzfeld studies have been done at over 10 different laboratories (Palmer, 2003; Parker, 2003). Though a significant but medium statistical likelihood of ESP ability has been reported so far, many researchers claim that there is insufficient evidence to support the existence of ESP. The conclusion is still controversial. The major problems for the ganzfeld studies are the inconsistent results, unpredictability and lack of progress (Alcock, 2003).

Likewise, the finger-reading effect is now facing the problem of replication. No-one has replicated Lee's finding using his training paradigm. All Western reviewed studies indicate that fingers might be able to recognise colours on paper, but are vulnerable to poor methodology as above. The methodological quality of a study is an important criterion for its inclusion in a meta-analysis (Rosenthal, 1995). For this reason, the author suggests that none of these seven studies can be selected in any meta-analysis. Plainly, if the finger-reading effect cannot be replicated reliably, it will lose credibility. Replication of the finger-reading effect with respect to recognising colours or print is wanting.

3.2.3.4 Experimenter effect

Another serious problem is that of the experimenter effect. Four ways that the experimenter can affect the results of experiments cannot be entirely excluded in all reviewed finger-reading papers: experimenter bias, experiment fraud, experimenter-participant interaction and experimenter's ESP ability.

3.2.3.5 Incomplete potential mechanisms and explanations

Attempts to explain the finger-reading effect have been made. One of the very important questions was, 'Can our skin see or perceive radiation?' For instance, perceiving light or radiation has been suggested as a possible normal explanation of the finger-reading effect. In one experiment (Barrett & Rice-Evans, 1964), the participants were given a dim and low-level visible light condition (0.00012 lumens/ cm^2). It was of 3.5 times the intensity of the black condition. No participant showed a significantly improved performance. Likewise, Kaiser (1983) let participants touch the coloured light passing through the heat-absorbing glass. No positive results were produced. The existing evidence indicates that human skin cannot "see."

Regarding detecting radiation, everything has its own radiation. In a paper with printed characters, the printed targets and the paper involve different materials. Thus, it is logical to infer that they have different radiation levels, which might, perhaps, lead to different levels of radiation feedback. Fingers might be able to detect the differences in radiation reflected by colours. To test this hypothesis, several attempts have been made. A higher level (60-W lamp) testing box comprising two compartments separated by a sheet of frosted glass was used (C. N. French, 1965).

Then a stack of 72 cards was put in the box. Black and white were used for the cards. The participant put one hand inside the box to go through the pack of cards and then guessed its colour under two conditions: one with the light on and the other one with the light off. No positive results were found. In another study (Passini & Rainville, 1992), blind and blindfolded participants were tested to see if they could discriminate colours in boxes under normal light condition, but the results does not support this idea.

Although many workers (Buckhout, 1966; Jacobson, Frost, & King, 1966; Markous, 1966; Nash, 1969, 1971; Novomeysky, 1965; Weintraub, 1966; Youtz, 1966; Zavala et al., 1967) support the hypothesis that human fingers might be able to detect radiation, all studies exhibit methodological problems. Kaiser (1983) pointed out that Buckhout's result is not significant. In Nash's, Novomeysky's and Zavala's studies, their methodological problems are as above. It was not clear if the experimenter was ignorant of the targets used in Jacobson's study. In Markous's study, only three of six participants used an aluminium box to prevent peeking. Youtz has not yet published a full account of his work, though he did use a blindfold as a safeguard. Again, they all did not provide fully detailed information of the experimental process and safeguards. Clearly, this hypothesis has not been supported.

On the other hand, Lee's team has made attempts to explain this finger-reading effect. They measured physiological responses, such as the positive electrical pulse near the end of the index finger, cerebral blood flow velocity and fMRI (Lee, 1998; Lee, Tang, Chen, & Fang, 2002; Tang et al., 2000; Wu et al., 2003). However, before proposing the explanations to account for this finger-reading effect, it must meet the two important criteria; that is, well developed controls against fraud and replication.

In conclusion, presumably, we need to investigate whether this finger-reading effect is measurable, then it could be appropriate to explore the basic properties of it in order to develop assumptions or theories to account for it.

3.3 Suggestions for improvements in methodology for finger-reading experiments

In general, the major problems with ESP experimental designs are: unwanted interpretations, poor observation, deception and sensory leakage (Hansen, 1990; Milton, 1996; Morris, 1999; Steinkamp et al., 1998). Similarly, there are three obvious methodological problems with these procedures. The first is randomisation. A target may not be randomly selected from the target pools. The second problem regards sensory leakage. The final is about participants and recording problems.

The major aim of this thesis is to investigate the validity of the finger-reading effects. Could it just be an example of cheating? How do we explain this effect if it is real? A better solution would be to replicate the finger-reading effect under tight controls in order to see if the finger-reading research could meet the requirement of replication. The author suggests adopting this paradigm originally developed by Si-Chen Lee to further explore this finger-reading effect, which will be modified and tested later by the author.

The author adopts the suggestion of providing a comfortable environment for working with children in order to obtain optimum performance from them in the training and testing procedures. In addition to maintaining a comfortable atmosphere, it is wise that possible fraud should also be excluded by eliminating inadequate controls. According to inadequate controls described before, the suggested improvements on Lee's finger-reading procedures are as follows:

3.3.1 Pilot trials

A pilot study ought to be conducted before a formal experiment, not only to maximise the possibility for participants to show their ESP ability but also to assess the efficacy of the controls that will be used in the formal experiment. In this regard, the author has carried out pilot trials[4] of finger reading in Taiwan. One of the main purposes was to check the entire training procedure in order to develop effective barriers against possible fraud in later experiments. The other purpose was to examine whether Lee's finger-reading effect had any potential for use in further work. Twenty-two participants aged from seven to eleven were recruited. They were trained to feel directly a two-digit number or a Chinese character on paper printed by an ink printer. The finger-reading task and stimulus material were the same as that described before.

Although the overall results of the author's pilot trials indicate a significant result, the finger-reading procedure was vulnerable to cheating. Peeking behaviours might occur when the participant touched the target in the black bag. Participants might have peeked at the samples through an opening of the two tight cuffs of the black bag by pulling at these two tight cuffs. Moreover, during the process of touching a target, the participants were allowed to remove their hands from the bag to write down their

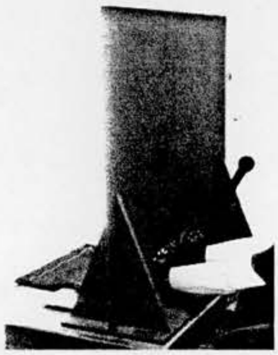
[4] Part of results of this pilot study has been presented at the 27th International Society for Psychical Research Conference (Shiah, Lee, & Morris, 2003)

answer; then they could put their hand back in the bag. This would increase the possibility of peeking behaviours. For these two reasons, the author will not report the results of these pilot trials in this thesis.

Before proposing the modified finger-reading training procedures, two problems need to be solved.

3.3.2 Peeking problem

Eight strategies are suggested to solve the peeking problem. First, the author has designed an effective barrier, which is an 80 cm (height) x 80 cm (width) black screen with two cuffs snugly tied around the forearms. The barrier has two holes for the forearms to be inserted through, before they then enter the black bag. The two holes of the screen are 8 cm in diameter and are 1.5 cm from the bottom. The distance between them is 15 cm. This screen can be set up on the table between the participant and the bag (Figure 3-3). Secondly, the author suggests at least one experimenter and one co-experimenter should closely monitor the participant, with one positioned each side of the barrier.



3-3a. The screen with two tight cuffs

3-3b. The screen set between the participant and the bag

Figure 3-3. The experimental Screen

Thirdly, experimenters and co-experimenters should make sure of the cuffs and that the barriers and bag are snugly tied/fitted around forearms of participants. Peeking can only take place if any gaps in the barrier-cuff and the bag-cuff are lined up exactly, as the participant could then conceivably peer through any small gap -- although this would be impossible to achieve without the observers immediately noticing the participant contorting his/her body in order to see through the gap. Fourthly, a part of the participant's arms should be exposed (Figure 3-3b). Thus, any attempts at lining up gaps in the cuffs of the bag and barrier will be easily observed. These modifications should make peeking impossible, but in addition, fifthly, the author suggests using a video camera to record the whole process. Thus, the possibility of unnoticed peeking, perhaps as a result of the experimenters and the co-experimenters not observing closely enough, could be ruled out. The ideal view for recording the process must include the cuffs of the bag and the screen (see Figure 3-3b), as these are the only possible areas where gaps could be lined up. The recorded data should be viewed by a different researcher to check if any peeking took place.

Sixthly, the trial should be considered invalid when participants pull at the tight cuffs of the bag or the screen to make openings. Seventhly, participants should not move their arms unnecessarily, or pull at the bag or cuffs during touching, to minimise possible peeking in terms of causing any openings of the cuffs of the bag and the screen.

Finally, the sample should be placed in a sealed opaque envelope to ensure the experimenter/co-experimenter and participants cannot see them and it is not opened until it has been inserted in the double-zipped bag. The sealed envelopes can be put in an opaque plastic bag. The purpose of a sealed opaque plastic bag is to avoid it being rendered transparent by the application of water, alcohol or oil. The opaque plastic bag can be put in a big envelope. This big envelope should be signed by the research assistant and be sealed by sellotape at its two ends so that any tampering would be detected. The envelope or plastic bag should be tested under sunlight or strong light to indicate that the targets cannot be seen. Under this condition, it is impossible to see any targets in the big envelope containing envelopes. Participants should not have a chance to see envelopes containing targets before or during the experiment. Under these arrangements, experimenters and co-experimenters too should not be able to see any targets.

3.3.3 Tactile cue problem

The other question to be addressed is whether tactile cue might account for the finger-reading effect. The tactile task used in the finger-reading studies and author's pilot trials involved ink-printed text, which is in a range of 1-20 microns (0.001-0.02 mm in elevation). The paper is hypothesised to absorb most of the ink, implying a near zero elevation. To verify this hypothesis, the surface topology of the printing in terms of four different colours was investigated by means of the novel 3D surface profiler instrument (Dektak 3, Veeco Instruments Inc.). The remarkable features of this instrument are its wide range of scanning area ($\sim$50 mm) and high vertical resolution ($\sim$0.01 nm). The horizontal axis and vertical axis of the printing were scanned to measure distance and vertical height respectively. The printing in terms of a two-digit number or a three letter English word was on a 5cm × 8cm rectangular pieces of paper (A4 white 75 g/m^2; H. E. Copier). Each digit or English letter size was 24 points in Times New Roman printed by a HP Officejet G85 colour printer. The result indicates that ink elevation and paper roughness cannot be distinguished, indicating a zero elevation. Note that previous finger-reading studies could not rule out tactile cue.

3.3.4 The modified finger-reading training procedures

In view of the peeking problem, tactile cue and inadequate controls described above, many safeguards will be used in the finger-reading processes in order to prevent possible fraud. The detailed materials and precise procedures for researchers to explore the finger-reading effect will be provided as an example.

3.3.4.1 Design

3.3.4.1.1 Pre-specifications

Hypotheses and analyses should be specified in advance. Experimenters have the right to declare a trial invalid if any of the following occurs:

(1) A participant takes the stimulus out of the black bag.

(2) A trial has been interrupted.

(3) The tight cuffs of the screen or bag are pulled at by participants to cause openings.

(4) A participant is unable to successfully open the envelope and extract the target under these "blind" conditions.

3.3.4.1.2 Barriers

The author suggests three kinds of barrier: the screen, the black bag and the video recorder.

3.3.4.1.3 Experimental room

The isolated room should be screened or guarded against peeking without windows, mirrors or holes. One experimenter, one co-experimenter and one participant should be in the room when conducting the experiments. The co-experimenter should give the participants the stimuli, and record their responses by a video recorder, as well as observing them. The experimenter will only record and observe participants' responses and behaviours. The author suggests that one experimenter and one co-experimenter stand each side of the screen (Figure 3-4). The participant's behaviour should be clearly monitored. Thus, the general guideline for the positions of an experimenter, one co-experimenter and a video camera is that the frame of observation must include a clear view of the participant's hand, cuffs and the bag. The best view for a video camera can be seen above. All participants' responses will be videoed in case the need for checking any details arises. Note that the author implemented the safeguard of video recording to reply to anonymous referees' suggestions to avoid poor human observation, when this Chapter was accepted by the Journal of Parapsychology. In the meantime, the experiment in Chapter 5 was nearly finished. Therefore, only some of the trials have been recorded. The detailed information will be noted in Chapter 5.

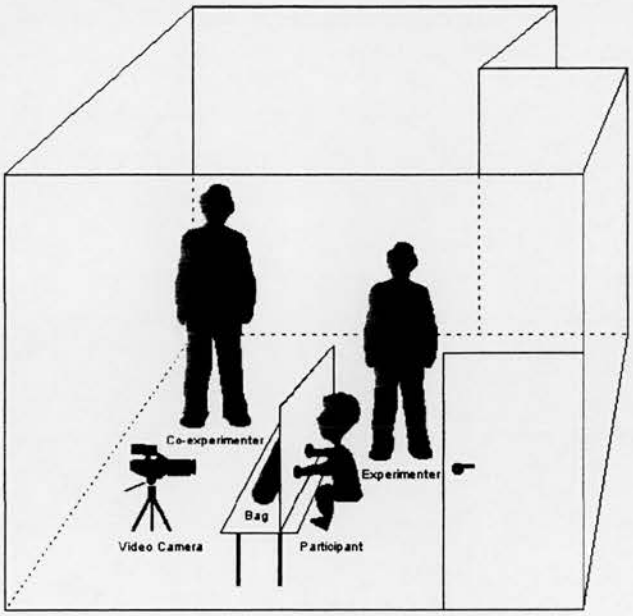


Figure 3-4. Participant, experimenter, co-experimenter and relevant equipment

3.3.4.1.4 Other controlled variables

Temperature should be controlled in a comfortable rage of between 20℃ and 27℃; dark condition is not suggested; and any noise should be eliminated, even possible patterned sound; unnecessary magnetic fields generated by any electronic machines should be excluded.

3.3.4.2 Participants

According to Lee's findings, participants aged seven to thirteen are promising recruits. Participants who have a history of nerve or brain injury, finger trauma, or learning disability (including dyslexia), diabetes (because of associated peripheral neuropathy) and calluses in their finger pads should be excluded.

3.3.4.3 Material (touch stimuli)

All experimental samples should be prepared in advance by a research assistant who will otherwise not be involved in the experiment. The co-experimenter who handles the target envelopes should have no relationship or contact with the assistant who prepared the targets.

The target stimuli should be produced in a strictly standard way: A two-digit number from 11 to 97 varying in four colours, i.e., red, green, blue and black can be printed in the middle of the paper. Numbers and their colours should be randomly generated by a computer generator designed by Paul Stevens, a research fellow of the Koestler Parapsychology Unit at Edinburgh University. The stimuli should be generated using a pseudorandom sort routine (based on the Microsoft Visual Basic RND function, seeded by the computer timer at the start of the program). The 75 numbers used are the same as Lee's. A number with a colour will be randomly selected as a replacement; thus, the same targets will possibly be repeated. In each trial, each target with a colour always has a 1 in 300 chance (mean chance expectation (MCE)) to be randomly selected by the computer programme. Subsequent trials will be chosen from the original pool, meaning these also have a probability of one in 300. Each trial will be independent from each other. Note that the randomness generated by pseudo-random generators has not been firmly supported (Schmidhuber, 2006; Wildermuth et al., 2005). Since this suggested randomisation is the most unpredictable randomisation: there are no patterns here that participants could possibly predict. This concern can be ignored.

Based on previous experience, usually, a participant could try 20 samples in a section within two hours. Thus, the computer generator will be set to generate a certain number of sets of 20 targets at once. Note that researchers can decide the number in each set as needed. All targets prepared for all participants will be generated in a single run by the computer generator. This means that the planned targets for all participants will be generated after running the computer generator in a single run.

The sample can be made up of 5cm × 8cm rectangular pieces of paper (A4 white 75 g/m^2; H. E. Copier). Each digit's size can be about 0.6cm × 0.5cm (Times New Roman, 24 points) printed by a HP Officejet G85 colour printer, which was confirmed to produce a zero elevation. It has been suggested that there is a close parallel spatial relationship between tactile character recognition and visual recognition (in millimetres) (Loomis, 1990). The size of the character is not crucial for a successful tactile identification but the bandwidth, namely visual legibility, is important. The digit size used here was very easy for visual identification; accordingly, it was presumed to be relatively good for tactile identification.

Each sample will have a fold with 1.5cm length on the top left corner (Figure 3-5) as a cue for participants to touch the target exactly. The person who prepares the samples will make a fold of 1.5cm length, using a meter scale to make sure of the right length. Sheets should be folded before the numbers with colours are printed on them to avoid possible frauds. The fold might be made slightly bigger if the number is higher, giving participants a cue to make a comparable judgment. Likewise, one could cut one corner of the paper to indicate which way is up.

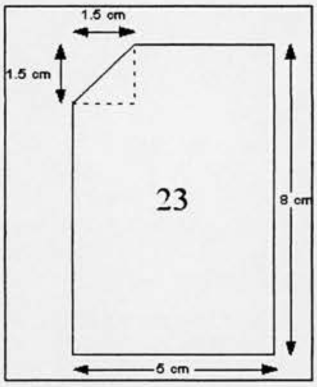


Figure 3-5. The target sample and its fold

Participants were informed by other means to help the orientation in pilot trials. They were told that the printing on the paper faces the front of an envelope and the bag and target is not upside down and the front of an envelope with a target facing the front (the zipper side) of the bag when it is put into the bag and target is not upside down. Some of the participants were confused about the orientation of the target in the "blind" condition. This might lead to a psychological effect on affecting participants' performance. This is the reason for why a fold is suggested to avoid this confusion.

Each stimulus is put into a sealed opaque envelope in a 15.2cm x 8.9cm size (Niceday envelopes: manilla plain 70gsm, gummed; product code: 182543, Guilbert company). The twenty envelopes in a pile are put in an opaque plastic bag. Each envelope is discreetly numbered, to aid double-checking of results. The opaque plastic bag can be put in a 22.9cm x 16.2cm opaque envelope (niceday envelopes: manilla plain 90gsm, gummed; product code: 183422, Guilbert company). This big envelope should be signed by the research assistant and be sealed by sellotape at its two ends so that any tampering would be detected by the co-experimenter who cuts open the envelope during the experiment.

The big envelope will not be opened until the experiment. These two envelopes or plastic bags were tested under sunlight to indicate that targets cannot be seen. It was found to be impossible to see any targets in the big envelope within the plastic bag containing the 20 envelopes. Each set of envelopes will be numbered faintly 1-20 (for experimenters' recording procedure only) by pencil on the outside, which is not detectable by touching. Each small envelope can be sealed with its gum, yielding no different feeling between envelopes. Each piece of paper needs to be placed exactly in the middle of each small envelope. The short side of the paper needs to contact the bottom of the envelope. The printing on the paper faces the front of an envelope, ensuring that the printing is not upside down (Figure 3-6).

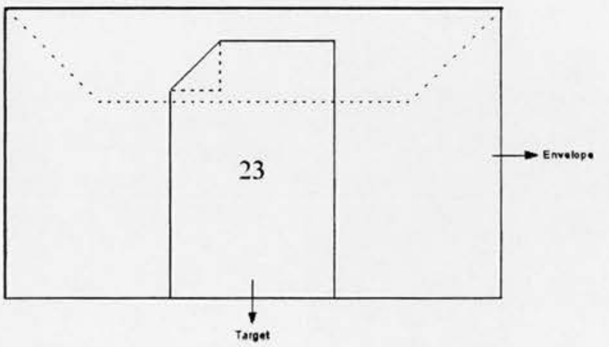


Figure 3-6. The target sample and its envelope

The stimuli, small envelopes, plastic bags and big envelopes should only be used once. Thus, participants cannot receive any target feedback marked on those materials by previous participants. The stimuli should be stored in a different room, to which neither participants nor the co-experimenter have access. Participants should not see any targets or their containers until receiving feedback. The research assistant who prepares the samples should save detailed information about the list of the stimuli in a secure computer and a soft copy in a sealed opaque envelope. Only this research assistant can access the computer and the sealed envelope containing the disk. This sealed envelope can only be opened after the experiment has been conducted. A double check of the stimuli after the experiment can be done to eliminate possible recording errors or cheating by replacing samples.

3.3.4.4 Procedures

3.3.4.4.1 Warm-up training before the finger-reading training

The training period should not exceed two hours a day due to children's limited attention. There can be a 15-minute break during each day of the study, during which participants can be rewarded with drinks or snacks.

The process begins with warm-up practice. First of all, the experimenter turns the light off. Participants will be required to sit and close their eyes and breathe deeply with a calm and peaceful mind for at least three minutes. The light will be put back on. Then participants will be required to practise "image making". The experimenter will show a red apple or other simple objects to the participants who will be asked to look at the apple very carefully and remember every detail of it. Then they will close their eyes to visualise the apple exactly as they perceive it. All children seemed able to perform this task in Lee's and the author's pilot trials. Once they can do this, they will try to visualise the apple changing its colour three or four times, i.e., through green, blue and black. Participants should also see a demonstration describing the "touch reading" phenomenon, such as how to identify the target.

3.3.4.4.2 Finger-reading procedure -- touching a two-digit number directly

Before the experiment, participants will be asked to show that their hands are empty and especially not concealing any trial samples used in the experiment. The co-experimenter should check the black bag is empty in between each trial. The purpose of these checks is to prevent conjuring tricks being used to conceal trial samples. Additionally, the participants should not be allowed to carry any mobiles or radio equipment to guard against any possible accomplice.

Participants can be given three to five practice trials. The experimenter will give the co-experimenter one big envelope containing a plastic bag containing twenty small envelopes. The co-experimenter will open the sealed big envelope. Then, the co-experimenter will take one small envelope from the plastic bag and put it in the black bag, and then close the zippers. The rest of the small envelopes will be kept in the plastic bag until required. Thus, participants will not see any envelopes during this process. Participants tended to avoid calling previous targets in guess sequence in ESP tasks (Ertel, 2005), although this guessing strategy cannot raise the probability of hit rate. Participants should be clearly informed the meaning of randomisation.

Next, participants will put their hands into the two tight cuffs of the screen and the black bag. They will be required to open the sealed envelope to take out a sample to scan targets using their fingers. Based on pilot trials, it was found to be easy and quick for participants to open the envelope to take the target paper out without tearing the paper or adding additional folds. Participants will be taught to tear the very end of right or left side of the envelope to take the target paper out, since the target paper will be in the middle of the envelope.

During the finger-reading training procedure, the participants will be required to focus on touch and to imagine that they can see the numbers while touching the target. They will be told that there is a fold in the top left corner as a cue for them to touch the target exactly. In addition, participants will be told not to add any additional folds or any marks on the target paper, so as to keep the targets intact. If necessary, it would be possible to have them checked later by another independent researcher to see if any obvious patterns of possible tactile cue were made by the person who prepares the targets.

There are no time restrictions and participants are free to use whatever scanning pressure and speed they choose. They will be asked to inform the co-experimenter about whatever they see and feel. They cannot take their hands out of the black bag during the touching procedure. Participants will be told that pulling at the bags or cuffs is not allowed, and to avoid any unnecessary movement of their arms. They can only take their hands out of the black bag after they tell the co-experimenter their final response. In the meantime, the co-experimenter and the experimenter will record the participant's responses and response times.

After the participant finishes the trial, the co-experimenter takes out the item from the black bag and shows the number with its colour to the participant. Participants therefore get feedback and the co-experimenter is able to record if the participant's response was correct. The reason for giving feedback is that participants are able to learn whether their judgments are accurate. It is hoped that this will help to induce and improve any finger-reading ability in terms of permitting a target-related image to come to mind. According to previous experience, children could try around 20 items within two hours. Each participant will try at least 80 samples in this experiment over four different days -- or more if time allows.

If participants want to have a break during the experiment, the co-experimenter should seal the big envelope containing a plastic bag containing the rest of samples and put it in another isolated room. The experimenter should lock the room, so that no one can access the room and the samples.

Note that the sequence of targets presented to participants should not be changed once they are generated. If a set of 20 targets cannot be completed by the former participant, the next participant can use the rest of them. Statistically, this action does not affect hit rates since the targets are selected randomly. The big envelope containing a plastic bag containing the unfinished samples should be signed by the co-experimenter and sealed by sellotape at its opened end. The experimenter should put the big envelope in another locked room.

If participants succeed in three consecutive correct recognitions of numbers with their colours, in addition to giving their verbal reports, they will be asked to draw on a sheet of paper the images they experienced during the recognition process. They will be asked to draw the whole image-forming process in detail. This might initially provide possible answers as to how children decide their responses in their minds and about the details of mental imagery. Three hits reach a significance ($p<0.05$, binomial test, MCE=1/300) when total trials are 245 for each participant. As a result, three hits could be a good judgment when total trials of a participant do not exceed 245.

It is suggested that the light might reduce the chances of recognising colours (Tang et al., 2000). Consequently, the author suggests using light while conducting the finger-reading studies. This issue of whether light is necessary for recognising colours should be further verified in later studies. In addition, participants will be given a brief summary of instructions during this session in Appendix 3, including the described instructions above.

3.3.4.4.3 Finger-reading procedure -- touching an English word directly

Earlier it was noted that seeing a 'screen' played an important and common role in successfully recognising targets while touching stimuli – the 'screen' was reported by the children to last for several seconds. There are two reported forms of screen: a transparent and an opaque screen. The transparent screen was activated when the children directly touched a two-digit number, and the opaque screen was more often activated as children directly touched a complex target. The author suggests that in future studies a complex target should be used, such as an English word.

Participants who report having seen a transparent screen with a positive result in the first experiment will be invited to take part in this experiment. The safeguard considerations, touching stimuli, barriers and procedures will be the same as described for touching a two-digit number directly. The warm-up procedure can be omitted in this study.

The target stimuli will be replaced by a three-letter meaningful English word in capitals. The data pool can include 1002 different three-letter English words derived from MRC Psycholinguistic Database (http://www.psy.uwa.edu.au/mrcdatabase/uwa_mrc.htm). A computer programme, again designed by Paul Stevens, can randomly choose the target word for producing samples, using a pseudorandom sort routine.

Similarly, if participants succeed in three consecutive correct recognitions in numbers with their colours, they will be asked to describe and draw how to get answers afterwards. Three hits reach a significance ($p<0.05$, binomial test, MCE=1/4008) when total trials are 3270 for each participant. As a result, three hits could be a good criterion when the total trials of a participant do not exceed 3270.

3.4 Considerations in conducting the finger-reading studies

3.4.1 General considerations

3.4.1.1 A comfortable environment

Extra efforts need to be made to arrange a comfortable environment, establish a warm rapport, and develop more fun short-time tasks. Each session should not exceed 50 minutes.

3.4.1.2 Motivating participants

Motivation is regarded as an important reinforcer in learning (Seitz & Watanabe, 2005). Three strategies are suggested for motivating participants. First, during experiments, children can be rewarded with drinks or snacks. The second strategy is that participants can receive verbal rewards and reasonable substantial rewards (Deci, Koestner, & Ryan, 1999), but will not receive any certificate from the researcher (R. Wiseman & Morris, 1995). Finally, experimenters have to get their participants to feel a real need to use psi and to have an intention to be involved in the experiment (Carpenter, 2005). Participants can be informed that the experimental results will help parapsychologists to understand the nature of possible psi functioning (R. Wiseman & Morris, 1995).

Note that too strong motivation is harmful to ESP learning (Tart, 1977b). One possible reason might be that too strong motivation leads to focus on oneself rather than tasks, resulting in lower performance (Kluger & DeNisi, 1996). Thus, to avoid the negative effects of motivating participants, the suggested strategies above are only for activating a moderate motivation in participants.

3.4.1.3 Feedback

As noted in Chapter 2, it has not been supported that ESP ability could be trained by feedback interventions with positive results. In fact, the effect of receiving feedback on ESP performance needs to be determined. The effects of feedback interventions on normal performance lead to an improved performance on average in a meta-analysis study, although about one third of studies giving feedback lead to lowered performance (Kluger & DeNisi, 1996). For this reason, the author initially assumes that this principle of positive feedback can be applied to the finger-reading learning for increasing performance.

The effect of giving immediate feedback on the finger-reading performance might cause pleasantness, frustration and arousal. The effects of negative and positive mood might have a harmful impact on performance. The arousal will lead to possible cognitive activities, such as attention in terms of exceedingly focusing on oneself (Kluger & DeNisi, 1996). These effects are destructive to the performance.

To avoid the negative effects of giving feedback on finger-reading performance, researchers should keep the following two purposes of feedback interventions in mind. The first is to activate moderate motivation in participants. The other purpose is that the information of feedback interventions is used to improve participants' visual images of targets. Participants should be reminded of these two points when necessary.

3.4.2 Ethical considerations

No reliable method for the training of ESP has yet been discovered. In addition, given the unknown nature of psi, clearly, we do not have any true knowledge of the limitations of ESP ability. Concerns regarding the ethical problems entailed in developing ESP ability have been little written about.

If we agree to the idea that psi might exist, the potential uses and influence of ESP are enormous. The goal of the experimentation undertaken for this thesis is to enable participants to learn the finger-reading ability. Pilot studies and two experiments are undertaken using participants' fingers to image seeing targets. When speaking with participants about experimental goals, it will be pointed out that the finger-reading training is probably conducive to the occurrence of psi imagery. It is unlikely that a person would experience this ability without using fingers; namely, this ability is restricted to only "touch". This is a very limited ability. The primary reason for giving this information to participants is to eliminate the fears that finger-reading ability might be manipulated for bad or good purposes. The other concern is that participants might have fears that they cannot control this ability. Under this condition, the author does not have any ethical worries about the experimental procedures.

The other possible impact of having this ability is an ethical concern of this thesis. Finger-reading ability has been studied for over a hundred years. No one has reported any negative or unpleasant experiences associated with this ability. The participants will be instructed that they can stop the training at any time, for whatever reason they wish. The ganzfeld rarely produces negative experience, and the induction in the finger-reading study is even milder than ganzfeld. Thus, it appears that the finger-reading training processes hold little possibility of the participant having an uncomfortable experience. From an ethical standpoint, the author believes the finger-reading training procedures have no known risks involved in this type of experiment.

Finally, before conducting the experiments, it is necessary to get permission from the children and their parents, as well as ethical committees. The general ethical guidelines can be seen in the Ethical and Professional Standards for Parapsychologist: Aspirational Guidelines developed by the Parapsychology Association revised in 2005 (Please see: http://www.parapsych.org/ethics.html).

3.5 Summary

This Chapter presents a modified finger-reading training paradigm under stringent conditions. The author proposes this standard paradigm in the hope of attracting more researchers and resources to use its safeguards and investigate the finger-reading effect, including the author's investigation. These finger-reading training procedures might still have limitations even under perfect safeguards. Three sources affecting ESP performance cannot be entirely eliminated. Briefly, the first is the *psi* ability of the participants or the experimenters. The second one is whether the experimenter's attitude of believing in *psi* or not might affect participants' ESP performance. The final possibility remains of experimenters or co-experimenters cheating, whether deliberately or unconsciously. The best possible way to eliminate potential fraud is via conducting replication studies by different researchers. In this consideration, this is another major reason for additional finger-reading studies to be undertaken, with a more universally agreed methodological approach.

Although this finger-reading training paradigm has been proposed, it will have been modified in the future due to undiscovered possibilities of fraud or newly developed machines for detecting cheating. Undoubtedly, this might be inevitable in the future but it is advantageous for later finger-reading studies in the long run.

Chapter 4. Experiment 1: Assessing the limits of tactile relief recognition

This study[5] concerns the extent to which people are able to recognise printed characters through the medium of touch. Even when appropriately strict experimental procedures are in place, a 'finger-reading' study which reports statistically significant levels of correct recognition scores among its participants may face a potential confounding variable. If experimental materials are designed in such a way that the digits or letter characters to be identified by participants are printed at a level of elevation beyond zero, then a participant's correct recognition may reflect not parapsychological abilities but, instead, a heightened level of tactile acuity. It follows that the only reliable way to determine whether the recognition of written digits can occur by parapsychological means is to set the level of elevation of printing for those digits at zero. When this value of elevation is used, if participants record statistically significant levels of correct recognition scores, then tactile acuity cannot be relied upon to explain such findings. For this reason, the studies described later in Chapters 5 and 6 utilised the zero level of elevation in preparation of experimental materials.

However, before going on to those studies, it is worthwhile pausing to consider the question of which levels of elevation beyond zero actually are detectable. Here this issue is not one of whether such detection arises out of either parapsychological ability or physical acuity. Rather, the issue here is to determine which levels of elevation in printed material are detectable at all.

It is worthwhile pursuing this question for several reasons. The first of these reasons is that, in the general literature on finger recognition of text, it has been shown that sighted people can distinguish Braille patterns of 0.3 mm in elevation, while people who are blind from an early age can identify Braille patterns of 0.2 mm in elevation. This suggests that, in addition to normal variations in adult human ability, there may be specific features of human experience which have an influence on an adult person's ability to recognize printed material through touch. This raises the interesting question of the extent to which a level of elevation in printed material can be reduced and yet remain detectable by some people.

A second reason lies in the suggestion made in Chapter 2 that children might have

[5] The main results of this chapter were submitted to the journal Experimental Brian Research on 15th July 2007 and it was suggested to be published by the reviewers but with required modifications. Now it is under revision.

superior tactile acuity due to their smaller finger size. The number of receptors remains constant over a period of a lifetime, so children's smaller fingers have a higher density of receptors. Men and women have the same numbers of tactile receptors, such as Meissner's corpuscles (Dillon et al., 2001). Women usually have a smaller finger size than men and have been shown to have superior tactile acuity than men in terms of GOT and tactile recognition tasks. The smaller size of finger would be expected to show superior tactile relief recognition in this experiment. This suggests that children might perform better in tactile relief recognition tasks than adults and women than men. However, there have been no previous studies of tactile relief recognition targeted at children as participants.

So independent of the question about whether parapsychological abilities enable some people to 'finger-read', it is worthwhile examining the question of what exactly the limits of tactile relief recognition are. In addition, it is useful to examine the question of whether children possess this ability to a greater extent than adults. The purpose of the study described in this chapter was to explore these two questions. In this study, it is hypothesised that the smallest elevation in a recognition task which leads to the participant successfully recognising the presented characters is below 0.5 mm. It was hypothesised that a tactile relief recognition of 0.3 mm or below would be observed in adults and children. To verify if these hypotheses hold true, six levels of tactile relief recognition task were developed. The decreasing relief conditions consisted of 0.5 mm in height, 0.4 mm, 0.3 mm, 0.2 mm, 0.1 mm, and 0.05 mm. Young adults showed a heightened tactile acuity of GOT compared to the older group. The grating orientation discrimination has a positive relation with tactile relief recognition. For this reason, the older group was not included in the research, while younger adults and children were included. Though children showed better spatial tactile acuity at gap discrimination than older and younger adults, no studies of tactile relief acuity have targeted children as subjects. The author wanted to ascertain whether there was any performance difference between children and adults via testing their limits of tactile relief recognition. The author also wanted to obtain data on the investigation of tactile relief capacity. Twenty four young adults and twenty four children were recruited in this study. The relationship between tactile experience and performance of tactile relief recognition was explored, because, superficially, this might provide explanations for tactile relief acuity, although this issue has never been studied before. All these questions are considered in this Chapter.

This result cannot explain how we can detect colours with the same elevation on the papers if finger-reading is valid. The major reason is that it involves the technical problem of making colours on the raised targets. In addition, based on the reviewed normal tactile function in Chapter 2, no results indicate that fingers can sense colours. For these two reasons, this concern can be ignored in this Chapter. This paranormal issue will be explored in later experiments in Chapters 5 and 6.

4.1 Experiment 1: Assessing the limits of tactile relief recognition

4.1.1 Hypotheses, exploratory questions and data analysis

The main hypotheses of this study concern the limits of tactile recognition. It was hypothesised that an elevation of less than 0.5 mm leads to successful tactile relief recognition, and that the lower limit for tactile relief recognition would be below 0.3 mm in adults. It is also suggested that children have superior tactile acuity due to a smaller finger size. This might suggest that children could perform better in tactile relief recognition tasks. In fact, there have not been any studies of tactile relief recognition using children so far. It was tested whether children could perform well in tactile relief recognition tasks with an elevation less than 0.3 mm.

Hypotheses 1 and 2 address the main concern of this experiment:

H1. Adults would show a threshold of below 0.3 mm elevation.
H2. Children would show a threshold of below 0.3 mm elevation.

Exploratory questions included: What is the relationship between finger size and tactile relief acuity? What is the difference between children and adults in tactile relief recognition tasks? What is the difference between women and men in tactile relief recognition tasks? What is the relationship between tactile experience and tactile relief recognition? Previous work has demonstrated that there were large differences in tactile acuity between participants (Vega-Bermudez et al., 1991). What are the differences between participants? Previous studies (Johnson & Phillips, 1981; Vega-Bermudez et al., 1991) had investigated the patterns of confusions between letters, but the patterns of confusions between digits have not been studied. What are the patterns of confusion of digits? What is the threshold of each digit?

The planned analyses were:

1. Under two choices with equal probability, a threshold success rate of 75% was considered as a standard psychophysical threshold because it was midway between chance (50%) and perfect performance (100%) (Van Boven & Johnson, 1994). This

threshold for each digit was determined by interpolating between elevations spanning 75% correct responses, unless performance is at 75% correct responses for a particular elevation. In this experiment the mean chance expectation is 11.1%; therefore, according to the proportion index π (Rosenthal & Rubin, 1989), a success rate of 27% for each digit in this experiment would be equivalent to a success rate of 75% under nine choices with equal probability.

2. The difference between women and men in tactile relief acuity was analysed using a two-tailed t–test.
3. The difference between children and adults in tactile relief acuity was analysed using two-tailed t–test.
4. The finger size, tactile relief acuity and tactile experience were examined by means of Spearman correlation coefficients.
5. The patterns of confusion were presented as confusion matrices (Vega-Bermudez et al., 1991).

4.1.2 Method

4.1.2.1 Participants

Twenty four child participants and twenty four young adults were studied. None of them had a history of nerve or brain injury, finger trauma, or learning disability (including dyslexia), and their finger pads were free of calluses. Participants having diabetes were excluded, because of associated peripheral neuropathy. None of the participants had previous experience in tactile letter identification. The child group consisted of 12 boys and 12 girls, with a mean age of 10.5 year (range 7 to 12 years; SD=1.68). All children were recruited from Hemei primary school in Taiwan. My supervisor wrote a letter (Appendix 4) to the principle of the Hemei primary school in Taiwan to get permission to put up a notice (Appendix 5) describing the experiment in the school, and possibly to give copies of the notice to teachers of classes in the appropriate age groups to send home with interested children to discuss with their parents. The informed parental consent form can be seen in Appendix 6. Twenty three child participants were right-handed and one child participant was left-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971). All of the children were tested in an isolated room in the Hemei primary school. The adult group involved 12 men and 12 women with a mean age of 21.25 (range 20 to 24 years; SD=0.99). All adults were right-handed based on the Edinburgh Handedness Inventory. Adult participants were recruited from the Chienkuo Technology University in Taiwan and were given an informed consent form. The notice for the adults was similar to the notice used for children (Appendix 5). The informed adult consent form was similar to the consent form used for children

(Appendix 6). All of the adults were tested in an isolated room in the Chienkuo Technology University. All experimental procedures were approved by the Ethics Committee of the Psychology Department at Edinburgh University for the protection of human participants. This experiment was administered, including preparing the samples, between March 2004 and June 2006.

4.1.2.2 Material

4.1.2.2.1 Personal information questionnaire

The personal information questionnaire included personal information and a tactual questionnaire (Appendix 7). Personal information contained demographical background and handedness according to the Edinburgh Handedness Inventory (Oldfield, 1971). All children were interviewed individually by the author with the questionnaire in order to make sure of their understanding of the questionnaire.

Tactual Questionnaire. Three questions were intended to gather information about the participants' tactual sensitivity. High scores indicated higher tactual sensitivity. Scores could potentially range from 3 to 21 by adding together the rating from Q1, Q1.1 and Q2.

1. If you touch something that you cannot see, such as in a darkened room, do you get a visual image of it? (7-point scale ranging from *not at all* to *very often*).

1.1 If yes, how clear is it? (7-point scale ranging from *not clear at all* to *as clear as using normal vision*)

2. How good do you think your touch sensitivity is? (7-point scale ranging from *not very well* to *very well*).
3. How many hours do you use a keyboard per day? (open question)

4.1.2.2.2 Measurement of finger size

Each participant's two index fingers were measured before the experimental tasks. The width of the finger was determined by measuring the width of the distal interphalangeal joint. The length of the finger pad was taken by measuring the distance between the very tip of the finger and the flexion crease at the distal interphalangeal joint. In comparing finger size, the rectangular area (length×width) was used (Dillon, *et al.*, 2001).

4.1.2.2.3 Touching stimuli

One pilot study was conducted to decide the final tactile stimuli. The sample was a 2.3 cm × 3 cm rectangular piece of paper. Embossed or printed in the middle of each piece of paper was one digit number. The 9 was excluded since the 6 is the same shape as 9. There were 9 numbers in total: 0, 1, 2, 3, 4, 5, 6, 7, and 8. The probability of correct identification by chance is 0.11. The sizes of the digits were the same as the sizes in a previous study (Vega-Bermudez et al., 1991). The stroke width of the digit was about 1 mm. The digit's height was 6.0 mm and the digits' widths ranged in from 2 mm for the digit 1 to 4 mm for the other digits. The height of 6.0 mm was used because it yields a performance level of 40-60 % correct judgment of Helvetica letters raised 1.5 mm above the ground in adult participants (Phillips, Johnson, & Browne, 1983). Most of the gaps used between strokes are longer than 0.05 mm, which is considered to yield chance performance of grating detection (Johnson & Phillips, 1981). Thus, the gap used in this study is appropriate. The original style (Myriad roman, 24 points) of the digits can be seen in Figure 4-1.

0	1	2	3	4

5	6	7	8

Figure 4-1. The original style of the digits

The tactile relief recognition conditions involved elevations of 0.5, 0.4, 0.3, 0.2, 0.1 and 0.05 mm. Due to the technical difficulty, the tactile relief recognition with elevations of below 0.05 mm can hardly be produced. The six levels of printing were produced using different level of dies to emboss the paper. The dies were made by the Lasercomb Dies and Palatine Engraving Co Ltd. The die was made of magnesium, supplied by Revere Graphics Worldwide, Inc (Figure 4-2). Because of commercial sensitivity, the way of producing dies is only briefly summarised as follows. There was a coating on the magnesium which is U.V.-light-sensitive. The image on the plate was exposed to harden the image area and then the plate was etched in an etching bath. The etching process used nitric acid which etched away the non-image areas on the plate leaving the image areas standing proud on the plate, which were then transferred to the substrate using inks or foil. The depth of the dies was controlled by a time and paddle speed measurement. The depth of the dies was measured by a dial indicator to check for correct depth.

Figure 4-2. The die for embossing digits

Embossed digits on the papers in terms of different levels of elevations were made by Foil Ribbon & Impact Printing Company. The depth of the dies was checked again by a micrometer before embossing. The embossing was carried out on a platen press which had a 30 ton impressional strength. A counter force using a thermal plastic was used to give exact registration, eliminating cutting through the paper which can be a problem with some designs and papers. After making the counter force, a sheet of the paper was inserted between the die and counterforce and closing the press pushed the paper between the counterforce and the embossing die and forms the embossed image. The paper used for embossing was colourplan 270g harvest plain (GF Smith & Son London Ltd), which was suggested as the most stable for embossing by the printing company because it has long fibres which are ideal for stretching into the embossed shape.

A presentation order of 6 levels of elevation was counterbalanced using a Latin Square design. This design is ideal for eliminating threats to internal validity when random assignment of participants is not possible. Specifically, the counterbalanced design diminishes potential differences by exposing all participants to all the conditions, while at the same time ruling out order-of-presentation effects (Isaac & Michael, 1995). In this Latin Square design (6 presentation orders of 6 levels of elevation), a full cycle of six presentation orders started over again after 6 participants finished their testing, in other words, the seventh participant was tested with the same order of condition presentation for the first participant. The sequence of targets was randomly generated by a computer generator designed by Paul Stevens, a research fellow in the Koestler Parapsychology Unit at Edinburgh University. The stimuli were generated using a pseudorandom sort routine (based on the Microsoft Visual Basic RND function, seeded by the computer timer at program start) and, as noted before, each digit was repeated six times at each level. Thus, each digit at each level of elevation was presented 6 times, which is similar to one previous study (Vega-Bermudez et al., 1991). Therefore, six trials for each digit used in this study are appropriate. Each participant has 54 trials at each level of elevation in each session. The total number of trials for each participant was 324. The method of concealing the samples in envelopes was the same as the method in Chapter 3. The stimuli, small envelopes, plastic bags and big envelopes were only used once to avoid possible sensory leakage. It took the participants three hours and 44 minutes to complete 324 trials on average.

4.1.2.2.4 Control of variables affecting tactile acuity

Temperature was controlled in a comfortable rage (23 ± 3℃). Normal light conditions were applied and any noise was eliminated, including any possible patterned sound. Visual imagery and feedback were not included. Participants were not able to see their hands, including their fingers, during the tactile tasks.

4.1.2.3 Safeguards, considerations and procedure

The detailed barriers (bag, screen and video recorder) and experimental room can be seen in the Chapter 3. One experimenter and one co-experimenter stand each side of the screen (Figure 3-4). The general guideline for the positions of an experimenter, one co-experimenter and a video camera is that the frame of observation must include a clear view of the participant's hand, cuffs and the bag. Before testing, participants were asked to name digits used in this study to minimise response biases, such as "I forgot to exclude 9 as a possibility." The author worked as an experimenter and a co-experimenter worked jointly to test all 48 participants in the same room. The safeguards, procedure and were the same as that described in Chapter 3, inclusive of concealing samples in envelopes and video recording the participants' responses.

The experimenter gave the co-experimenter one big envelope containing a set of envelopes. The co-experimenter opened the sealed big envelope. Then, the co-experimenter took one small envelope from the big envelope and put it in the black bag, and then closed the zippers. The rest of the small envelopes were kept in the big envelope by the experimenter until required. Thus, participants did not see any envelopes during this process. Participants were clearly informed of the meaning of randomization by the experimenter. Next, participants put their hands into the two tight cuffs of the screen and the black bag. They were required by the experimenter to open the sealed envelope to take out a sample. They were taught by the experimenter to tear the very end of right or left side of the envelope to take the target paper out, since the target paper was in middle of the envelope.

During this task, participants were only required to focus on touching on the surface of a plate of the screen and to see if they could feel the number on the paper without any instruction. Since no difference between passive and active touch was observed (Craig, 2002; Phillips et al., 1983; Vega-Bermudez et al., 1991), they were allowed static touch or as many scans as they wish in either one direction or both directions and to use whatever scanning force and velocity they chose, using whatever combination of wrist and finger movement they desired. Participants were required by the experimenter to identify the digits using the finger pad on the plate to minimize other sensory input such as occurs when using the nail, palm or other phalanges. They were required by the experimenter to scan the digits within the sample size (2.3 cm × 3 cm). The movement of participant's hands was restricted on the plate. No feedback was given by the experimenter in this task. Responses such as "I do not know" were not allowed. The varied motor information between the participants can be minimised. On each trial, the participants were asked to report their answer or guess by the experimenter. In the meantime, the co-experimenter will record the participant's responses.

4.2 Results

Participants' responses, including the experimenter's record, the original data and recorded video data were double-checked by an independent researcher. No peeking was found to be involved by any of the 48 participants. The overall rate of correct responses is presented in Table 4-1.

Table 4-1 Overall mean rate of correct responses

Elevations(mm)	0.05	0.1	0.2	0.3	0.4	0.5
Participants						
Adults(n=24)	47.4%	48.1%	48.8%	53.8%	57%	63.7%
	(SD=.13)	(SD=.17)	(SD=.13)	(SD=.14)	(SD=.15)	(SD=.14)
Children(n=24)	34.3%	36.6%	35.1%	35%	39%	44.2%
	(SD=.13)	(SD=.15)	(SD=.13)	(SD=.12)	(SD=.16)	(SD=.14)

Hypotheses 1 and 2 predicted below 0.3 mm threshold would be observed in adults and children. As noted before, a success rate of 27 % in this experiment would be equivalent to a success rate of threshold of 75%. Both groups of children and adults show a success rate of above 27 % at all elevations. Hypotheses 1 and 2 are supported.

The correlation between finger size and tactile relief acuity is displayed in Table 4-2. As can be seen, Table 4-2 did not show any significant relationship between finger size and tactile relief acuity.

Table 4-2 Correlation between finger size and tactile relief acuity (N=48)

Tactile relief acuity (elevations (mm))	0.05	0.1	0.2	0.3	0.4	0.5
Finger size	.175	.131	.222	.161	.272	.113

Child participants had a smaller finger size of 2.93cm^2 (SD=.76) compared to adult's finger size of 3.52cm^2 (SD=1.11) ($t=2.12$, $df=46$, $p<0.05$). The mean difference of overall mean rate of correct responses of adults and children can be seen in Table 4-1. Using a two-tailed t–test, the adult group performed better in all tactile relief recognition tasks than the child group (0.05 mm elevation, $t=3.43$, $df=46$, $p<0.01$; 0.1 mm elevation, $t=2.48$, $df=46$, $p<0.05$; 0.2 mm elevation, $t=3.51$, $df=46$, $p<0.01$; 0.3 mm elevation, $t=4.88$, $df=46$, $p<0.001$; 0.4 mm elevation, $t=4.08$, $df=46$, $p<0.001$; 0.5 mm elevation, $t=4.95$, $df=46$, $p<0.001$).

Women had a smaller finger size of 2.78cm^2 (SD=.76) compared to men's finger size 3.67cm^2 (SD=.91) ($t=3.48$, $df=46$, $p<0.01$). The two-tailed t tests of mean difference of overall mean rate of correct responses of men and women can be seen in Table 4-3. There was no significant gender effect.

Table 4-3 t test of overall mean rate of correct responses of men and women

Elevations(mm)	0.05	0.1	0.2	0.3	0.4	0.5
Participants						
Men(n=24)	44.0%	45.4%	43%	46.6%	52.2%	55.1%
	(SD=.15)	(SD=.18)	(SD=.16)	(SD=.16)	(SD=.17)	(SD=.17)
Women(n=24)	37.7%	39.4%	40.4%	42.1%	43.9%	53.5%
	(SD=.14)	(SD=.15)	(SD=.13)	(SD=.17)	(SD=.18)	(SD=.18)
Two-tailed t test (df=46)	1.5(p=.14)	1.2(p=.22)	0.6(p=.54)	1.0(p=.35)	1.7(p=.11)	0.3(p=.76)

The relationship between overall mean rate of correct responses rate and responses on the tactual questionnaire is displayed in Table 4-4. The result indicates that there was no significant relationship among overall mean rate of correct responses, and the responses to tactile questions one and two. There was a significantly positive relationship between the period of using a keyboard, at the 0.3 mm and 0.4 mm elevations. Of course, given the relatively large number of correlations tested, this result must be treated with a great deal of caution.

Table 4-4 Correlations between overall mean correct response rates and tactual questionnaire (N=48)

Elevations(mm)	0.05	0.1	0.2	0.3	0.4	0.5
Touch Questions:						
1.Get a visual image of touching something that you cannot see	-.093	-.045	.035	-.075	-.135	-.115
1.1 If yes, how clear is it	.006	-.043	.163	.015	-.008	-.004
2.How good your touch sensitivity?	.18	.07	-.044	-.146	.02	-.157
3.How many hours using a keyboard per day?	.156	.171	.275	.322*	.312*	.272

*p<0.05

Table 4-5 shows that there is a large difference in recognising eight digits with six levels of elevation between participants. The largest difference in performance is 81% in recognising digits with 0.1 mm elevation in adults. The smallest difference of performance is 48% in recognising digits with 0.3 mm elevation in adults and children.

Table 4-5 Performance (mean rate of correct responses) levels of the participants

	Adults(N=24)		Children (N=24)	
	Minimum	Maximum	Minimum	Maximum
Elevations(mm)				
0.05	28%	76%	13%	72%
0.1	13%	94%	20%	76%
0.2	24%	76%	15%	61%
0.3	35%	83%	17%	65%
0.4	33%	87%	15%	74%
0.5	32%	89%	28%	76%

The threshold for each digit is displayed in Table 4-6. The threshold for the digits can be determined by interpolating between elevations. If the hit rate of digits is less than 27% at 0.5 mm elevation, the threshold is indicated as >0.5 mm. By contrast, if the hit rate of digits is more than 27% at 0.05 mm elevation, this was indicated as <0.05 mm. Most of the digits are below 0.05 mm threshold in the adults, except the 5(0.17 mm) and 6(0.34 mm). Only 1, 7 and 0 are below the 0.05 mm threshold in the children, whilst the other digits are the 2 and 3 at 0.19 mm, 8 at 0.17 mm, 4, 5 and 6 at >0.05 mm.

Table 4-6 The threshold (mm) of each digit

	1	2	3	4	5	6	7	8	0
Adults(N=24)	<0.05	<0.05	<0.05	<0.05	0.17	0.34	<0.05	<0.05	<0.05
Children (N=24)	<0.05	0.19	0.19	>0.5	>0.5	>0.5	<0.05	0.17	<0.05

The raw data consisted of a pooled 9 × 9 confusion matrix for six elevation levels of 9 digits. Figures 4-3, 4-4, 4-5, 4-6, 4-7 and 4-8 illustrate confusion matrices representing the responses of adults and children. The negative diagonal represents correct responses. The frequency of presentation of the digits is shown on the rightmost column. The bottom row shows the overall frequency (%) of the responses for each digit.

A: Adults

	Response 1	2	3	4	5	6	7	8	0	
Stimulus										
1	**141**	.	.	.	.	.	2	.	1	144
2	2	**45**	41	9	20	**8**	10	6	3	144
3	2	20	**44**	8	23	22	5	17	3	144
4	**8**	**8**	10	**71**	7	20	12	3	5	144
5	1	13	45	11	**39**	10	1	22	2	144
6	1	10	23	16	17	**33**	1	29	14	144
7	31	5	1	**8**	1	2	**96**	.	.	144
8	4	4	21	**18**	18	17	1	**49**	12	144
0	2	2	7	10	6	12	.	9	**96**	144
	192(15)	107(8)	192(15)	151(12)	131(10)	124(10)	128(10)	135(10)	136(11)	1296

B: Children

	Response 1	2	3	4	5	6	7	8	0	
Stimulus										
1	**132**	1	1	2	1	.	6	.	1	144
2	9	**37**	14	7	10	18	23	13	13	144
3	17	20	**32**	17	7	15	15	16	5	144
4	28	19	9	**29**	10	14	14	9	12	144
5	11	23	29	12	**17**	**8**	10	23	11	144
6	8	19	14	9	6	**23**	5	25	35	144
7	36	13	2	6	6	9	**61**	5	6	144
8	6	11	17	9	11	17	6	**38**	29	144
0	12	9	12	8	3	5	5	13	**77**	144
	259(20)	152(12)	130(10)	99(8)	71(6)	109(8)	145(11)	142(11)	189(15)	1296

Figure 4-3. Pooled confusion matrices for participants in the 0.05 mm elevation task. A: pooled confusion matrix for adults. B: pooled confusion matrix for children

The similarity of the participants' performance in the two groups can be seen by examining the matrices on a cell-by-cell basis. The rank order of digits from the least to the most frequently correct is 107482356 in the adults and 107823465 in children.

A: Adults

	Response									
	1	2	3	4	5	6	7	8	0	
Stimulus										
1	**131**	1	.	1	.	.	10	.	.	144
2	1	**49**	18	11	23	22	5	11	4	144
3	3	19	**51**	5	29	13	3	20	1	144
4	10	12	10	**62**	11	17	9	4	9	144
5	1	13	41	4	**35**	22	1	25	2	144
6	.	4	16	15	18	**40**	.	38	13	144
7	18	6	2	9	1	4	**103**	.	.	144
8	1	3	14	12	12	22	1	**55**	24	144
0	.	2	5	13	4	9	5	7	**99**	144
	165(13)	109(8)	157(12)	132(10)	133(10)	149(12)	137(11)	161(12)	153(12)	1296

B: Children

	Response									
	1	2	3	4	5	6	7	8	0	
Stimulus										
1	**135**	.	1	1	1	1	3	3	2	144
2	7	**33**	31	10	15	10	12	15	11	144
3	5	12	**42**	3	10	19	9	34	10	144
4	28	21	15	**20**	7	19	9	9	16	144
5	4	23	30	7	**10**	17	6	37	10	144
6	2	12	15	9	2	**32**	3	41	28	144
7	27	5	4	6	4	16	**74**	.	8	144
8	1	5	14	16	6	24	3	**51**	24	144
0	4	7	7	8	4	12	4	20	**78**	144
	213(16)	118(9)	159(12)	80(6)	59(5)	150(12)	123(10)	207(16)	187(14)	1296

Figure 4-4. Pooled confusion matrices for participants in the 0.1 mm elevation task. A: pooled confusion matrix for adults. B: pooled confusion matrix for children

The rank order of digits from the least to most frequently correct is 170482365 in the adults and 107823645 in children.

A: Adults

	Response									
	1	2	3	4	5	6	7	8	0	
Stimulus										
1	**142**	.	.	.	.	.	1	.	1	144
2	1	**54**	26	6	22	14	12	3	6	144
3	4	29	**40**	12	16	21	7	13	2	144
4	4	14	12	**64**	16	16	6	5	7	144
5	.	8	53	5	**33**	19	.	26	.	144
6	.	6	19	18	18	**26**	1	32	24	144
7	7	12	.	11	3	5	**103**	.	3	144
8	.	5	24	7	17	14	.	**74**	3	144
0	1	3	4	10	5	14	3	7	**97**	144
	159(12)	131(10)	178(14)	133(10)	130(10)	129(10)	133(10)	160(12)	143(11)	1296

B: Children

	Response									
	1	2	3	4	5	6	7	8	0	
Stimulus										
1	**130**	.	4	2	1	1	3	.	3	144
2	12	**42**	21	7	9	14	21	12	6	144
3	31	19	**29**	10	7	17	12	16	3	144
4	9	20	13	**29**	13	24	10	12	14	144
5	13	20	40	11	**7**	14	4	30	5	144
6	3	12	14	11	10	**27**	5	27	35	144
7	22	11	7	7	4	9	**77**	1	6	144
8	4	6	19	13	12	24	4	**46**	16	144
0	6	6	17	6	3	22	4	12	**68**	144
	230(18)	136(11)	164(13)	96(7)	66(5)	152(12)	140(11)	156(12)	156(12)	1296

Figure 4-5. Pooled confusion matrices for participants in the 0.2 mm elevation task. A: pooled confusion matrix for adults. B: pooled confusion matrix for children

The rank order of digits from the least to most frequently correct is 170842356 in the adults and 170824365 in children.

A: Adults

	Response									
	1	2	3	4	5	6	7	8	0	
Stimulus										
1	**138**	.	.	.	.	.	5	.	1	144
2	1	**59**	31	11	17	14	5	4	2	144
3	.	20	**50**	6	30	15	5	15	3	144
4	.	8	8	**85**	12	20	5	5	1	144
5	.	14	32	6	**38**	24	3	27	.	144
6	1	7	17	14	14	**31**	1	28	31	144
7	18	5	1	4	1	3	**111**	.	1	144
8	.	6	19	14	16	10	1	**69**	9	144
0	.	1	2	3	9	7	.	5	**117**	144
	158(12)	120(9)	160(12)	143(11)	137(11)	124(10)	136(11)	153(12)	165(13)	1296

B: Children

	Response									
	1	2	3	4	5	6	7	8	0	
Stimulus										
1	**126**	2	.	3	.	2	9	.	2	144
2	9	**35**	24	14	10	13	20	9	10	144
3	14	25	**37**	**8**	13	12	10	20	5	144
4	5	25	14	**37**	12	20	10	13	8	144
5	3	18	46	10	**12**	11	13	24	7	144
6	7	10	12	13	**8**	**18**	4	24	48	144
7	39	12	3	5	3	11	**63**	2	6	144
8	2	14	22	14	6	13	3	**42**	28	144
0	5	4	9	14	4	7	6	12	**83**	144
	210(16)	145(11)	167(13)	118(9)	68(5)	107(8)	138(11)	146(11)	197(15)	1296

Figure 4-6. Pooled confusion matrices for participants in the 0.3 mm elevation task. A: pooled confusion matrix for adults. B: pooled confusion matrix for children

The rank order of digits from the least to the most frequently correct is 107482365 in the adults and 107843265 in children.

A: Adults

	Response									
	1	2	3	4	5	6	7	8	0	
Stimulus										
1	**142**	1	.	.	.	.	1	.	.	144
2	.	**67**	32	5	19	12	4	3	2	144
3	1	16	**61**	8	31	9	1	17	.	144
4	.	16	8	**72**	18	15	5	7	3	144
5	.	7	38	5	**50**	21	.	22	1	144
6	.	5	13	19	21	**41**	2	24	28	144
7	18	3	.	6	1	1	**115**	.	.	144
8	.	2	17	9	12	27	.	**67**	10	144
0	.	6	.	5	3	1	.	5	**124**	144
	161(12)	123(10)	169(13)	129(10)	146(11)	127(10)	128(10)	145(11)	168(13)	1296

B: Children

	Response									
	1	2	3	4	5	6	7	8	0	
Stimulus										
1	**139**	.	.	.	.	1	3	.	1	144
2	1	**50**	21	8	19	9	10	15	11	144
3	8	18	**44**	10	13	17	8	20	6	144
4	6	21	24	**35**	13	16	7	7	5	144
5	2	16	37	12	**9**	17	1	47	3	144
6	5	11	10	13	7	**22**	3	27	46	144
7	38	7	6	8	5	5	**67**	2	6	144
8	2	5	15	20	8	19	2	**50**	23	144
0	1	7	5	12	1	8	5	15	**90**	144
	202(16)	135(10)	162(13)	118(9)	75(6)	114(9)	106(8)	193(15)	191(15)	1296

Figure 4-7. Pooled confusion matrices for participants in the 0.4 mm elevation task. A: pooled confusion matrix for adults. B: pooled confusion matrix for children

The rank order of digits from the least to the most frequently correct is 107482356 in the adults and 107823465 in children.

A: Adults

	Response 1	2	3	4	5	6	7	8	0	
Stimulus										
1	**140**	.	.	.	.	.	4	.	.	144
2	.	**75**	23	4	19	16	3	.	4	144
3	5	16	**64**	8	19	16	3	13	.	144
4	1	15	9	**82**	10	15	3	9	.	144
5	.	10	34	6	**59**	16	.	19	.	144
6	.	1	7	10	11	**49**	.	35	31	144
7	3	7	.	.	3	4	**127**	.	.	144
8	.	2	6	4	20	27	.	**87**	9	144
0	.	.	.	.	.	1	.	1	**142**	144
	149(12)	126(10)	143(11)	114(9)	141(11)	133(10)	140(11)	164(13)	186(14)	1296

B: Children

	Response 1	2	3	4	5	6	7	8	0	
Stimulus										
1	**138**	.	.	.	.	.	6	.	.	144
2	3	**49**	28	4	9	25	12	7	7	144
3	10	16	**49**	5	12	17	9	19	7	144
4	8	16	10	**36**	14	21	17	13	9	144
5	1	20	35	9	**12**	12	1	48	6	144
6	2	4	10	9	7	**24**	4	27	57	144
7	12	15	3	7	1	9	**87**	4	6	144
8	.	2	13	7	15	18	3	**54**	32	144
0	2	1	.	6	1	4	2	3	**125**	144
	176(14)	123(10)	148(11)	83(6)	71(6)	130(10)	141(11)	175(14)	249(19)	1296

Figure 4-8. Pooled confusion matrices for participants in the 0.5 mm elevation task. A: pooled confusion matrix for adults. B: pooled confusion matrix for children

The rank order of digits from the least to the most frequently correct is 107842356 in the adults and 107823465 in children.

Children and adults had a similar rank order of digits form the least to the most frequent confusions. Considering the poorer recognition rate of digits (the threshold >0.05 mm, see Table 4-6), the most frequent distractors for 5 were 3 and 8 and the most frequent distractors for 6 were 8 and 0 in adults. For children, the most frequent distractors for 5 were 3 and 8; the most frequent distractors for 4 seemed to be evenly distributed in other digits; the most frequent distractors for 6 were 0 and 8; the most frequent distractors for 8 were 0 and 6; the most- frequent distractors for 2 were 3 and; the most frequent distractors for 3 were 8 and 2.

4.3 Discussion

The threshold was shown to be between 0.05 mm and zero for 1, 2, 3, 4, 7, 8 and 0 in young adults, and between 0.05 mm and zero for 1, 7 and 0 in children. A threshold above 0.5 mm for 4, 5 and 6 could be observed in the children, whilst the other digits are the 2 and 3 at 0.19 mm and 8 at 0.17 mm. Note the investigation would have had technical problems in producing samples below 0.05 mm and zero. This might be solved by improved techniques in the future. It is expected that children will fail to recognise digits with elevations between 0.05 mm and zero, except 1, 7 and 0.

The main finding is that children showed inferior recognition of raised digits, especially in recognizing digits requiring fine spatial resolution. The result is contrary to the prediction that children have heightened recognition of raised digits. Most tactile acuity studies use adults as participants and few use children as participants. The issues in the early development ranging from 0 to 20 years of tactile acuity are little known, though one prior study (J. C. Stevens & Choo, 1996) reported that children have superior tactile acuity at gap discrimination. This superior tactile acuity at gap discrimination differs from the ability to resolve fine spatial form. The gap discrimination has the edge within a gap varying in size. Participants indicate whether there is a gap or not while an edge is pressed into their skin. Clearly, the gap discrimination cannot provide a measure of fine spatial resolution. The grating orientation discrimination test (GOT) and tactile relief recognition provide a reliable measure of fine spatial form.

Though a child's brain at the age of 12 is the same size as an adult's in terms of folding, weight and regional specialisation (Powell, 2006), it is still immature (Barnea-Goraly et al., 2005; Gogtay et al., 2004; Shaw et al., 2006; Sowell et al., 2004). One of the possible explanations for why children have poorer tactile relief recognition might be the immaturity of their cortical areas, including sensory mechanisms, but no relevant data are available. Immaturity might lead to differences in the way that tactile information is integrated in the tactile neural pathway. Based on the result of patterns of confusion and the threshold of each digit, children seemed to perform poorly in recognising digits requiring fine spatial resolution, such as 2, 3, 4, 5, 6 and 8. This indicates that children might have immaturity in fine spatial form of neural mechanism. In light of children's poorer fine digits recognition, among the four types of tactile receptors, the type 1 slowly adapting (SA1) system might be more immature in children than the other three tactile receptors. It is logical to assume that children would perform poorly in the GOT as a significantly positive relationship between performance on GOT and on embossed letters was reported (Vega-Bermudez & Johnson, 2001). Other possible explanations might involve cognitive skills or motivational factors. More research is needed.

Previous studies indicate that women performed better in tactile acuity than men (Goldreich & Kanics, 2003; Van Boven et al., 2000). It was predicted that women would have a heightened tactile relief acuity due to their smaller finger size. The women with a smaller finger size did not show superior tactile recognition of digits in this study. Finger size and gender might not be good predictors of tactile recognition. It remains premature to make a conclusion based on only this study with its small size of sample.

There were significantly positive relationships between the period of using a keyboard and tactile relief tasks at 0.3 and 0.4 mm. Using a keyboard might enhance the tactual relief acuity, which is similar to the result of people who played piano having superior tactual acuity to those who did not play (Ragert et al., 2004). People who have a certain hand skill might have better tactile sensitivity because of the effect of tactile practice. Previous studies (Grant et al., 2000; Sathian & Zangaladze, 1998; Vega-Bermudez et al., 1991) support the notion that tactile practice enhances tactile acuity. However, it should be noted that these significantly positive relationships between the period of using a keyboard and tactile relief tasks might be spurious significant correlations given that a relatively large number of correlations were tested. More research is wanted.

The result indicates that there is a large difference in recognising raised digits between participants with a range of 48% to 81%, similar to the previous studies using embossed letters (Johnson & Phillips, 1981; Loomis, 1981; Phillips et al., 1983; Vega-Bermudez et al., 1991). There is not any ready explanation to account for this large difference in recognising raised digits. It might be due to skin mechanisms. The ability of the skin compliance to spatial details of surfaces of objects has been found to account for 50% of variance in a measure of GOT (Vega-Bermudez & Johnson, 2004). The other possible explanations might be differences in innervation density of tactile receptors (J. C. Stevens & Choo, 1996; Van Boven & Johnson, 1994; Vega-Bermudez & Johnson, 2004; Vega-Bermudez et al., 1991) or psychological differences (Vega-Bermudez et al., 1991), such as cognitive skills or motivational factors.

With regard to the poorer hit rate for digits 5 and 6 observed in adults and for 2, 3, 4, 5, 6 and 8 observed in children, they all need fine resolution of tactile neural representation. One common aspect of their confused recognition patterns lies in the similar shapes. For example, based on the pooled confusion matrices, there is evidence that all participants quite often mistook 3 for 5 and the child group quite often mistook 7 for 1. The author assumes that the neural representation of a tactile, scanned 5 is more like a 3 than a 5 in all participants and scanned 7 is more like a 1 than a 7 in children. This might be because that participants were given no feedback and no previous experience in tactile letter identification, so their judgements must have been based on comparisons of tactile impressions with visual memories of these numbers (Vega-Bermudez et al., 1991). It is suggested, if giving feedback or training, that participants would rapidly learn the characteristic answer triggered by each digit (Vega-Bermudez et al., 1991)

It was suggested at the beginning of this chapter that it is worthwhile trying to determine which levels of elevation in printed material are detectable by human fingers. First, there is prior evidence that adults vary in their abilities in this respect: this raises the question of the extent to which print elevation can be reduced and yet remain detectable at least by some people. Second, the physiological evidence reviewed in Chapter 2 indicates the possibility that people with relatively small fingers (e.g. children in comparison with adults, and women in comparison with men) might prove to be especially adept at dealing with low levels of elevation. Somewhat surprisingly, the evidence presented here suggests that although such variation in ability exists, it is not related to age or to gender.

As was pointed out earlier, this issue can be considered independently of the question of whether such abilities are grounded in normal or in paranormal perception. In this respect, the present chapter can be taken as presenting useful background information to those with a research interest in the elevation levels of printed materials (e.g. those involved in the study of the effectiveness of Braille materials). In particular, such researchers would be wise to attend to the finding that there is a relatively wide (but unexplained) variation in human abilities in this domain. However, they would also be wise to note that the apparently sensible assumption that those with small fingers are especially adept is, in fact, unfounded.

In noting that these matters can be considered independently of the question of whether such abilities are grounded in normal or in paranormal perception, one point is especially important. There is no evidence presented in this chapter to establish whether the variability in ability which was detected was due either to normal perceptual processes or to paranormal processes. In other words, the lack of significant differences between adults and children and between men and women indicates that there is neither a normal (e.g. physiology-based) nor a paranormal difference in the perceptual abilities of these groups. A range of abilities *was* detected across the sample as a whole. But there is, likewise, no evidence presented in this present chapter to indicate whether these differences are due to as-yet unexplained normal perceptual processes or to paranormal processes. This latter point requires especial care. The range in abilities described in this chapter is described in terms of differing abilities to identify text at different levels of elevation. But nothing in the procedures followed in this chapter settles the question of whether the differences noted were caused by differences in normal or paranormal perceptual abilities. As was argued at the beginning of this chapter, the only way for the researcher to avoid such a potential conflict in explanation is to ensure that research materials are produced which have a zero level of elevation. It is this procedure which is followed in the next two chapters.

So the present chapter indicates, then, that there are unexplained variations in ability which might be attributed to paranormal causes. It is this possibility which is explored in the following two chapters. However, as will be seen there, no evidence is presented to support claims of paranormal abilities. In this respect, then, it seems that the variations described in the present chapter are perhaps more safely attributed to differences in normal perceptual abilities which require to be explored in future research. In this respect, the findings presented in this chapter may offer some valuable insight to future research in non-parapsychological areas such as the study of how Braille texts can be best implemented.

4.4 Conclusions

The author obtained data on the investigation of tactile relief capacity via conducting a study in which six levels of relief recognition task of nine digits were used. The decreasing relief conditions consisted of 0.5 mm in height, 0.4 mm in height, 0.3 mm in height, 0.2 mm in height, 0.1 mm in height and 0.05 mm in height. 24 adults and 24 children were recruited in this study. The overall results indicate that the mean threshold of levels of elevation in the nine digits recognition task is below 0.05 mm, suggesting that a true threshold between 0.05 mm and zero still needs to be determined in the future research.

The performance of recognising eight digits at all six elevations was significantly lower in the child group compared to the adult group. Poorer tactile relief acuity in children may represent an immature tactile mechanism. Ageing, therefore, has an important effect on the tactile acuity and nervous system.

Based on the results, children cannot recognise digits below 0.05 mm, except 0, 1 and 7. Regarding applying this result to the later finger-reading studies with the intention of eliminating the tactile cue of raised targets, the best way is to use samples with a zero elevation when conducting finger-reading experiments in Chapters 5 and 6.

Chapter 5. Experiment 2: Finger-reading training - Touching a two-digit number

One of the primary goals of the following experiment[6] is to replicate the finger-reading effect under well-controlled conditions. The author has adopted the paradigm originally derived from Si-Chen Lee, which now is modified and improved in Chapter 3. The previous studies show that 24% of unselected participants demonstrated a significant ability to identify a target when touching it directly after training. It is proposed that the potential key to ESP ability might lie in "subjectively seeing a vivid screen with right answers" (Lee, 1998, 1999).

Seeing a screen played an important and stable role in successfully recognising targets while touching stimuli, which was reported by the children to last for several seconds. There are two forms of screen: a transparent and an opaque screen. The transparent screen was activated when the children directly touched a two-digit number, and the opaque screen could be activated as children directly touched a complex target. This visual experience was assumed to act as "clairvoyance" (Lee, 1999). The ability of seeing an opaque screen was considered to be an important requirement for recognising complex targets. Precisely, the experience of seeing screens means that the participants saw visual image of right targets. Similarly, the most convincing evidence of correct remote perception of target-related images involved in ESP are ganzfeld technique, remote viewing (Dunne & Jahn, 2005; Puthoff & Targ, 1976) and spontaneous cases (Honorton et al., 1974; Roll & Persinger, 1998; Stanford, 1974a, 1990; Stevenson, 1970).

However, the finger-reading effect of touching targets directly has not yet been tested and replicated by other researchers, and this training model has not been implemented in any Western culture. As noted before, only individual sum of scoring has been reported in Lee's finger-reading studies. The result of overall sum of scoring of all participants in Lee's finger-reading studies is unknown. Individual and overall scoring should be provided, which would allow other researchers to examine the results, using suitable analyses. It was unknown how many participants had these two kinds of experiences of seeing a transparent and/or an opaque screen. Do these two kinds of experience exist? Does this kind of experience have the same displaying process among the participants? Is it a perfect predictor that the participants who experience a screen would perform better than those who do not? Do the transparent and opaque screens share the same displaying process? Do participants who see an

[6] The main results of this chapter have been accepted by the Journal of Parapsychology for publication.

opaque screen score more hits and recognise more complex characters? The best solution would be to trigger this finger-reading ability through training in order to study the basic properties of it, such as the forming and displaying process of seeing answers.

Despite the various measures relating to ESP discussed in Chapter 1, there have been no studies exploring this with children. The relationship between belief in paranormal and ESP has been studied in adult populations and has been found to have a significantly positive relationship. It would make sense to study this issue in children, including background variables. Some touch questions regarding tactile experience in Chapter 4 were studied. They might provide some clues for explaining the finger-reading effect.

5.1 Experiment 2: Touching a two-digit number directly

5.1.1 Hypotheses, exploratory questions and data analysis

This study will examine formal hypotheses and exploratory questions as follows. The main hypotheses of this study concern the children's performance when directly touching the targets. In previous work, only individual scoring has been reported, with 24% of participants showing a significant result. Lee contended that, after finger-reading training for eight hours, 24% of children had a significant result for identifying a two-digit number varying between four different colours through touching by means of activating their experience of a "screen." In that case, hypothesis 1 addresses the main concern of this experiment – nearly 25% of participants, after eight-hour training, would achieve a significant result and above-chance scoring of recognising numbers with colours would be elicited. Hypothesis 2 concerns the issue of learning whether improvement of recognising numbers with colours would be observed from the beginning to the end of finger-reading training in recognising numbers with colours.

Hypotheses 3 and 4 concern the existence of relevant visual experience and the appearance of a visual screen. In Lee's report, some participants subjectively reported having seen a visual screen with an image of the right answer overlapping their normal vision while they were touching the target, no matter whether the children had open or closed eyes. Clearly, to the best of our scientific knowledge, this visual experience is quite different from real vision, presumably indicating the existence of a new form of visual experience. Hypothesis 3 predicted improved scoring of recognising numbers with colours after subjectively experiencing a visual screen.

Lee argued that children who experience seeing a vivid screen bearing the right answer would have better scoring of recognising numbers with colours than those who did not. In view of that, hypothesis 4 predicted that participants' scoring would significantly improve after acquiring the ability to see a screen while touching a target -- performing better than children not reporting having seen a screen.

Exploratory questions included the following. Firstly, as noted before, only individual scoring was reported. What is the result of overall scoring? Secondly, what is the result of hits for numbers? What is the result of hits for colours? Thirdly, would improvement in recognising numbers or colours be observed from the beginning to the end of finger-reading training? The fourth exploratory question is about visual imagery and visual experience during finger reading. The literature does not as yet suggest how many children have reported this experience, nor was a congruent experience among them mentioned. What percentage of children will report mental imagery? Will children who visualise a 'screen' experience it in similar ways? What is the nature of visual experience when followed by successful identification while touching targets? What is the relationship between a screen experience and the result of hits of colours or numbers?

Another exploratory question concerns ESP belief and psi hitting. The sheep-goat effect is one of the early concepts developed to understand the relationship between ESP belief and psi hitting. The sheep group (who believed in the possibility of ESP) had a better ESP score than the goat group (who did not believe in the possibility of ESP). So what is the relationship among hit rate and mental imagery, paranormal beliefs and tactile experience? Finally, is there an experimenter effect on the participants' finger-reading performance, in that a relationship exists between the experimenter's ESP belief and hit rate? So what is the relationship between the experimenter's ESP belief and hit rate? Additionally, the data might suggest further questions needing exploration.

The planned analyses were:

1. Overall hit scoring of each participant was analysed by means of a binomial, two-tailed test.
2. Overall hit scoring of all participants was analysed by means of a binomial, two-tailed test.
3. Overall hit scoring of all participants and each participant was analysed by means

of the effect size, π (Rosenthal & Rubin, 1989), if the overall hit rate is significant as indicated by binomial test.

4. Across-sessions, hit rates of colours, numbers and numbers with colours were displayed by a graph.
5. The hit rate of colours, numbers and numbers with colours of all participants was examined for across-session hit rate of colours, numbers and numbers with colours by means of an ANOVA (repeated-measures design).
6. The hit rate of colours, numbers and numbers with colours of each participant was examined for across-session hit rate of colours, numbers and numbers with colours by means of an ANOVA.
7. The difference in scoring between participants reporting having seen a screen and participants before they have learnt to see a screen was analysed by means of a two-tailed t-test.
8. The difference in scoring between participants reporting having seen a screen and participants not reporting having seen a screen was analysed by means of a two-tailed t-test.
9. Hit scoring, imagery questions, paranormal beliefs, finger size, touching questions and background variables were examined by means of Spearman correlation coefficients.

5.1.2 Method

5.1.2.1 The experimenter and co-experimenters

The experimenter was the author. One experimenter, one co-experimenter and one participant were in the room throughout the experiment. The co-experimenter gave the participants the stimuli and recorded their responses by video recorder, as well as observing them. There were five co-experimenters involved in this experiment, all of them students at Edinburgh University.

5.1.2.2 Participants

Eighteen participants, eight boys and ten girls, joined in the training process and five participants went through the entire training programme based on daily sessions of two hours over a four-day period. The participants were individually tested in an isolated room in the Psychology Department of Edinburgh University. The age range was from 7 to 12 (M=9.67, SD=1.94). Fourteen participants were right-handed and four participants were left-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971). All children were recruited from the Sciennes primary school in Edinburgh. My supervisor wrote a letter (Appendix 8) to the headteacher of the Sciennes primary school to get permission to put up a notice (Appendix 9) describing the experiment in the school, and possibly to give copies of the notice to teachers of classes in the appropriate age groups to send home with interested children to discuss with their parents. The informed parental consent form can be seen in Appendix 10. The announcement included an introduction to these tactual tasks, the purpose of the training and a consent form for parents. The participants were informed that this study was approved by the Psychology Department Ethics Committee of Edinburgh University as suitable for children, and the experimenters had the necessary Disclosure (Scotland) Certificates (showing they had no criminal records).

Participants' sexes, ages and handedness are presented in Table 5-1. No one had a history of nerve injury, finger trauma or learning disability, and their finger pads were free of calluses.

Table 5-1 Participants' sex, age and handedness

Participant	Sex	Age	Handedness
S1	Girl	12	Right
S2	Girl	7	Right
S3	Girl	7	Right
S4	Boy	10	Left
S5	Boy	11	Left
S6	Boy	7	Right
S7	Girl	11	Right
S8	Boy	10	Right
S9	Girl	10	Left
S10	Boy	11	Left
S11	Girl	7	Right
S12	Girl	11	Right
S13	Boy	7	Right
S14	Boy	12	Right
S15	Girl	12	Right
S16	Girl	11	Right
S17	Boy	10	Right
S18	Girl	8	Right

Based on the original training period, it is suggested that participants would obtain the best performance when they participate over an intensive continuous four days with a daily two-hour training programme. All participants were encouraged to take an intensive four-days training for eight hours. No one could join the experiment without such an intensive period. Usually, the duration of all sessions was one week. All participants were paid £2.50 for each session of two hours.

5.1.2.3 Material

The personal information questionnaire includes personal information, imagery questions, belief in the paranormal and touch questions. Personal information will include demographical background and handedness (See Appendix 11).

Imagery Questionnaire. Imagery questions were extracted from an existing questionnaire instrument previously developed within the Koestler Parapsychology Unit. There were five questions before the experiment. Responses were made by ticking a box on a 7-point scale, in response to the following question. High scores indicated higher mental imagery. Scores could potentially range from 5 to 35.

1. How easy is it to create a mental image of a familiar scene? (7-point scale ranging from *impossible* to *effortless*).
2. If you can create a mental image of a familiar scene, how clearly can you see the scene? (7-point scale ranging from *not at all* to *as clear as using normal vision*).
3. How well can you hear a sound in a mentally imaged scene? (7-point scale ranging from *not at all* to *very well*).
4. How well can you imagine smelling something? (7-point scale ranging from *not at all* to *very well*).
5. How easily can you experience a taste in a mentally imagined scene? (7-point scale ranging from *not at all* to *very well*).

Tactual Questionnaire. Four questions were intended to gather information about the participants' tactual sensitivity. High scores indicated higher tactual sensitivity. Scores could potentially range from 3 to 21 by adding together the rating from Q1, Q3 and Q4. Note that the rating scale for the clarity of the images of Q3 was used in Chapter 4 (See Appendix 7, Q7.1). However, this rating scale was not used in this study because of the author's ignorance. This impact of this neglect will be discussed more later.

1. How well can you imagine feeling something through touching? (7-point scale ranging from *not at all* to *very well*).
2. How many hours do you use a keyboard per day? (open question)
3. If you touch something that you cannot see, such as in a darkened room, do you get a visual image of it? (7-point scale ranging from *not at all* to *very often*).

4. How good do you think your touch sensitivity is? (7-point scale ranging from *not very well* to *very well*).

Belief in the paranormal questionnaire. Beliefs in paranormal experience questions were extracted from an existing questionnaire instrument previously developed within the Koestler Parapsychology Unit. There were five questions. High scores indicated higher belief. This study also investigated the relationship between the experimenter's (and co-experimenters') beliefs in the paranormal and the participants' hit-rates. For this reason, the experimenter and co-experimenters were administered this questionnaire (see Appendix 12). Scores could potentially range from 5 to 35.

1. Do you believe in the existence of ESP (extrasensory perception: reception of information without the use of known senses or logical inference)? (7-point scale ranging from *impossible* to *certain*).
2. Have you ever had an experience which is best explained by telepathy (ESP in the thoughts, feelings or behaviour of another person or organism)? (7-point scale ranging from *yes* to *no*).
3. Have you ever had an experience which is best explained by clairvoyance (ESP for distant physical events or concealed objects)? (7-point scale ranging from *yes* to *no*).
4. Have you ever had an experience which is best explained by precognition (ESP for the future)? (7-point scale ranging from *yes* to *no*).
5. Do you believe in the existence of PK (psychokinesis: mental influence on the physical world)? (7-point scale ranging from *impossible* to *certain*)).

5.1.2.4 Finger-reading task, barriers and experimental room

The finger-reading task and stimulus material were the same as that described in Chapter 3. Note that Chapter 3 was accepted by the Journal of Parapsychology for publication in the middle of carrying out this experiment, to which the author finally added the safeguard of video recording. Therefore, only some of the trials have been recorded in this experiment. The detailed discussion for this issue will be presented later. All experimental samples were prepared in advance by a research assistant who otherwise was not involved in the experiment. The co-experimenter who handled the target envelopes had no relationship or contacted with the assistant who prepared the targets.

The detailed barriers (bag, screen and video recorder) and experimental room can be seen in the Chapter 3. One experimenter and one co-experimenter stand each side of the screen (Figure 3-4). The general guideline for the positions of an experimenter, one co-experimenter and a video camera is that the frame of observation must include a clear view of the participant's hand, cuffs and the bag.

5.1.2.5 Procedure

Before the finger-reading training procedures, all children were interviewed individually by the author and a co-experimenter (a native speaker) together using the questionnaire in order to make sure of their understanding of this questionnaire. The terms *telepathy*, *clairvoyance*, *precognition*, and *psychokinesis*, were all well defined for the participants.

The training period did not exceed two hours a session, due to children's limited attention. There was a 15-minute break during each hour of the study, during which participants can be rewarded with drinks or snacks. The process began with warm-up practice. First of all, the experimenter turned the light off. Participants were required to sit and close their eyes and breathe deeply with a calm and peaceful mind for at least five minutes. The light was put back on. Then participants were required by the experimenter to practice "image making". The experimenter showed a red apple or other simple objects to the participants, who were asked to look at the apple very carefully and remember every detail of it. Then they closed their eyes to visualise the apple exactly as they perceived it. It was found in the author's previous trials that all children seemed able to perform this task. Once they can do this, they tried to visualise the apple changing its color three or four times, i.e., through green, blue and black. Participants also saw a demonstration by the experimenter describing the "touch reading" phenomenon, such as how to identify the target.

5.1.2.5.1 Finger-reading training procedures

The finger-reading training procedures were administrated between June 2005 and February 2006. The author worked as an experimenter and a co-experimenter worked jointly to test all 18 participants in the same room. The safeguards, procedure and can be seen in Chapter 3.

Participants were given three to five practice trials in the first session. The experimenter gave the co-experimenter one big envelope containing a plastic bag containing twenty small envelopes. The co-experimenter opened the sealed big envelope. Then, the co-experimenter took one small envelope from the plastic bag and put it in the black bag, and then closed the zippers. The rest of the small envelopes were kept in the plastic bag by the experimenter until required. Thus, participants did not see any envelopes during this process. Participants were clearly informed of the meaning of randomization by the experimenter.

Next, participants put their hands into the two tight cuffs of the screen and the black bag. They were required by the experimenter to open the sealed envelope to take out a sample to scan targets using their fingers. Participants were taught by the experimenter to tear the very end of right or left side of the envelope to take the target paper out, since the target paper was in middle of the envelope.

During the finger-reading training, the participants were required by the experimenter to focus on touch and to imagine that they can see the numbers while touching the target. They were told that there is a fold in the top left corner as a cue for them to touch the target exactly. There were no time restrictions and participants were free to use whatever scanning pressure and speed they choose. They were asked to inform the co-experimenter about whatever they saw and felt. They cannot take their hands out of the black bag during the touching procedure. Participants were told by the experimenter that pulling at the bags or cuffs was not allowed, and to avoid any unnecessary movement of their arms. They can only take their hands out of the black bag after they told the co-experimenter their final response. In the meantime, the co-experimenter and the experimenter recorded the participant's responses and response times.

After the participant finished the trial, the co-experimenter took out the item from the black bag and showed the number with its colour to the participant. Participants therefore got feedback. If participants wanted to have a break during the experiment, the co-experimenter sealed the big envelope containing a plastic bag containing the rest of samples and put it in another isolated room. The experimenter locked the room, so that no one can access the room and the samples.

However, one safeguard was not used and two safeguards were only partially applied in this experiment. The fold of the paper for a cue for orientation was not made before the targets were generated. The independent researcher who prepared samples might have deliberately or unconsciously made a bigger folder indicating a bigger number. The possibility was ruled out via later checking that no obvious patterns in the folding of the paper were found by another independent researcher.

The following two safeguards were partially used in this study. The first is that most of the participants were not asked to show their hands were empty. The participants might have concealed trial samples used in the experiment. Another independent researcher has checked all items against the original data and found no evidence of replacing targets by any of the participants. Thus, the possibility of replacing original targets can be ignored. Secondly, only 87 of 1395 trials were videotaped and all these 87 trials found no peeking was involved. The remaining 1308 might have involved peeking because of neglect by the two researchers. One might speculate that the possibility of peeking led to a significant possibility of recognising targets. As will be reported later, no significant effect of recognising targets was found, so this concern can be disregarded.

5.2 Results

Participants' responses, including the experimenter's record, the co-experimenter's record, and the original data were double-checked by an independent researcher. The data keyed in to the computer was double-checked by an independent researcher.

Participants' questionnaire results are shown in Table 5-2. Individuals were classified as easily making imagery, psi believers or good at touch if on more than half of the relevant ratings they rated in the range 5-7. Most of the participants (89%) reported they were good at creating a visual image of a familiar scene, and sixteen participants (94%) reported they saw the scene of creating a visual image clearly. Over half of the participants (61%) reported they were very good at receiving a sound from a mentally imaged scene; eight participants (44%) reported they were very good at receiving a smell from a mentally imaged scene; seven participants (39%) reported they were very good at receiving a taste from a mentally imaged scene. 61% reported imagining feeling something well through touching and good tactual sensitivity. 50% reported getting a visual image when you touch something that you cannot see. As to paranormal beliefs, 13 participants (72%) reported they believed in the existence of ESP; 28% reported they had had an experience of telepathy; 17% reported they had had an experience of clairvoyance; 12 participants (67%) reported they had had an experience of precognition; 7 participants (39%) reported they believed in psychokinesis.

Table 5-2 Participants' questionnaire results (N=18)

Questionnaire	Number (and percentage) of participants giving ratings of 5 or more on each item	M (SD)
1. Imagery questions		
1.1 Easy to create a mental image of a familiar scene	16 (89%)	5.8(.99)
1.2 The mental image is clearly seen	17(94%)	5.8(.71)
1.3Perceive auditory components of a mentally imaged scene well	11(61%)	5.4(1.65)
1.4 Perceive olfactory gustatory components of a mentally imaged scene well	8(44%)	4.0(1.91)
1.5 Perceive gustatory components of a mentally imaged scene well	7(39%)	4.2(1.86)
2.Tactual questions		
2.1Imagine feeling something well through touching	11(61%)	5.17(1.79)
2.2 How many hours they use a keyboard per day		0.65(.16)
2.3Get a visual image when you touch something that you cannot see	9(50%)	4.6(1.75)
2.4 Good touch sensitivity	11(61%)	5.17(1.34)
3. Beliefs in paranormal		
3.1 Belief in the existence of ESP	13(72%)	4.89(1.53)
3.2 Any experience of telepathy	6(28%)	4.50(2.38)
3.3 Any experience of clairvoyance	3(17%)	2.50(1.80)
3.4 Any experience of precognition	12(67%)	4.50(2.15)
3.5 Existence of psychokinesis	7(39%)	3.78(1.83)

As experimenter's and co-experimenters' questionnaire results can be seen in Table 5-3, all experimenter and co-experimenters reported they are believers in ESP (belief in the existence of ESP). Although all the co-experimenters, including the experimenter, believed in ESP, no significant results of the participants' performance were found. It is logical to infer that there might be no experimenter effect on the participants' performance.

Table 5-3 Experimenter's and co-experimenters' questionnaire results (N=6)

Beliefs in paranormal	M (SD)
1 Belief in the existence of ESP	5.86(0.90)
2 Any experience of telepathy	5.57(1.27)
3 Any experience of clairvoyance	3.86(1.77)
4 Any experience of precognition	5.29(2.14)
5 Existence of psychokinesis	5.58(1.14)

Hypothesis 1 predicted twenty-five percent of participants would achieve a significant result in recognising numbers with colours within eight hours of training. All participants were encouraged to come to this study as many times as they could. It was inevitable that the child participants came to this study at varied times resulting in varied trials. The length of each session for the participants varied: 30 minutes, one hour, one and half hours and two hours. Usually, it took the participants one hour to attempt 10 items. It is reasonable to assume that 80 trials take eight hours to meet the requirement of eight-hour training suggested by Lee. Only five of the participants tried over 80 items, as seen in Table 5-4. The major reason for failing to reach this requirement was that children felt the programme was somewhat tedious and time-consuming. For the testing of Hypothesis 1, the null hypothesis was that the probability of a correct response was 0.0033. The exact binomial test was used and the binomial probability was estimated via poisson approximation if n (trails)(>1,000) is large (Robinson, 1985). All five participants who went through eight-hour training did not significantly show the finger-reading ability in recognising a two-digit number with a colour as well as the rest of the participants. Hypothesis 1 is not supported. In addition, the overall result did not show any significance.

Table 5-4 Participants' trials, hits of numbers with colours, and subjectively seeing a screen

Participant	Total no. of trials	Total no. of hits (percentage) of recognition of a two-digit number with a colour (MCE=1/300, 0.33%)	*p* (two tailed)	Subjectively reporting seeing a screen like an external
P1	108	0(0%)	1	No
P2	46	0(0%)	1	Yes
P3	54	0(0%)	1	Yes
P4	35	0(0%)	1	Yes
P5	143	1(0.7%)	0.38	Yes
P6	40	0(0%)	1	Yes
P7	73	0(0%)	1	Yes
P8	39	0(0%)	1	Yes
P9	91	0(0%)	1	Yes
P10	20	0(0%)	1	Yes
P11	35	0(0%)	1	Yes
P12	9	0(0%)	1	No
P13	45	0(0%)	1	No
P14	370	0(0%)	1	Yes
P15	27	0(0%)	1	No
P16	63	0(0%)	1	Yes
P17	182	2(1.1%)	0.12	Yes*
P18	15	0(0%)	1	No
Total Trials	1395	3(0.2%)	0.65	

*Subjectively reported seeing images with answers after 54 trial

Similarly, no significant results were found in recognising colours and numbers, as seen in Table 5-5. The probability of a correct response for recognising a colour was 0.25 and for recognizing a digit was 0.0133.

Table 5-5 Participants' trials, hits of colours or numbers

Participant	Total no. of trials	Total no. of hits (percentage) of recognition of a colour (MCE=1/4, 25%)	p (two-tailed)	Total no. of hits (percentage) of recognition of a two-digit number (MCE=1/75, 1.33%)	p (two-tailed)
P1	108	28(26%)	0.82	1(0.9%)	1.00
P2	46	8(17%)	0.31	0(0%)	1.00
P3	54	15(28%)	0.64	0(0%)	1.00
P4	35	13(37%)	0.12	0(0%)	1.00
P5	143	39(27%)	0.56	2(1.4%)	0.72
P6	40	11(28%)	0.72	0(0%)	1.00
P7	73	14(19%)	0.28	0(0%)	1.00
P8	39	10(26%)	0.86	0(0%)	1.00
P9	91	26(29%)	0.47	1(1%)	1.00
P10	20	4(20%)	0.80	1(5%)	0.23
P11	35	9(26%)	1.00	1(3%)	0.37
P12	9	2(22%)	1.00	0(0%)	1.00
P13	45	9(20%)	0.50	2(4.4%)	0.12
P14	370	102(28%)	0.25	1(0.3%)	0.10
P15	27	9(33%)	0.37	0(0%)	1.00
P16	63	20(32%)	0.24	0(0%)	1.00
P17	182	37(20%)	0.17	3(1.7%)	0.52
P18	15	5(33%)	0.55	0(0%)	1.00
Total Trials	1395	361(26%)	0.47	12(0.9%)	0.16

Hypothesis 2 predicted that participants would significantly improve their finger-reading ability from the beginning to the end of finger-reading training. According to Lee's work, two-hour training was considered as a session, suggesting taking 20 trials. Across-session analysis of hit rate of numbers with colours is displayed in Figure 5-1. Apparently, Figures 5-1 did not show any trends or patterns of improvement with practice. The existing data do not support Hypothesis 2.

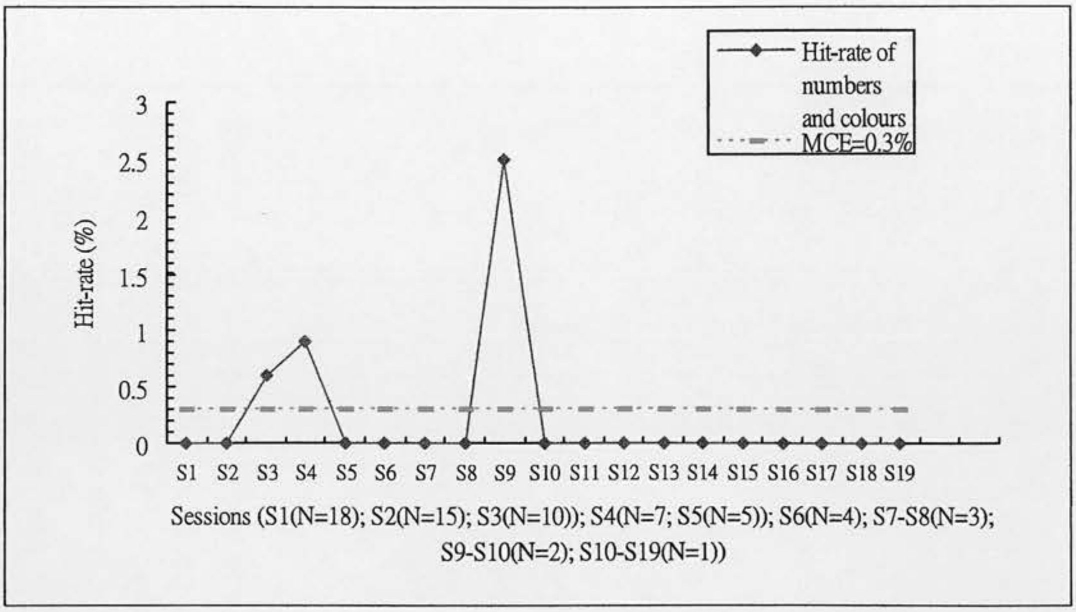


Figure 5-1. Across-session analysis of hit-rate of numbers with colours

Across-session analysis of hit-rate of colours and numbers are displayed in Figure 5-2 and 5-3, revealing no trends or patterns of improvement with practice.

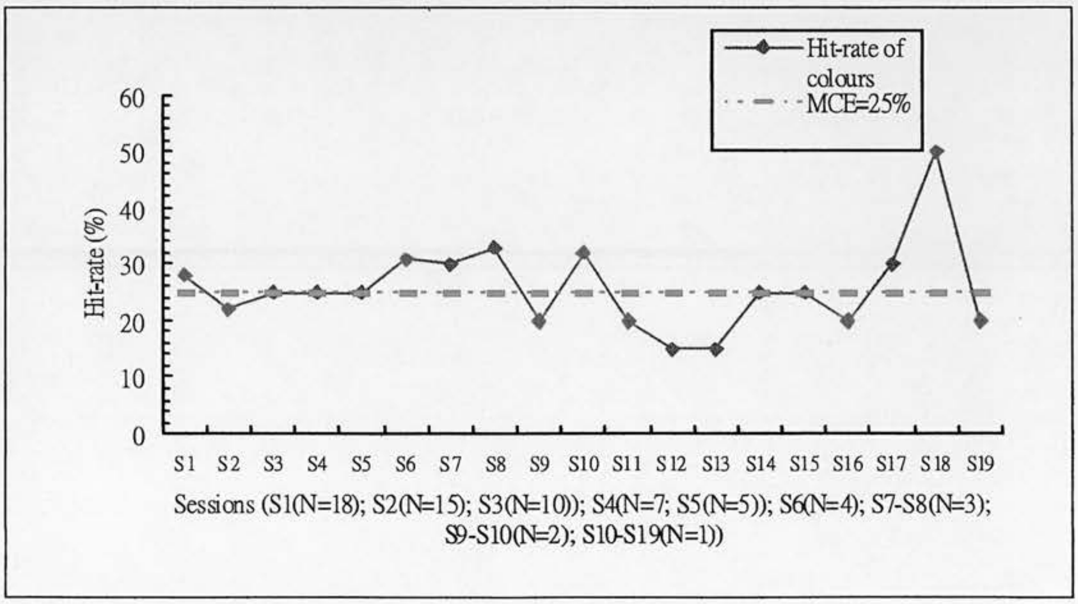


Figure 5-2. Across-session analysis of hit-rate of colours

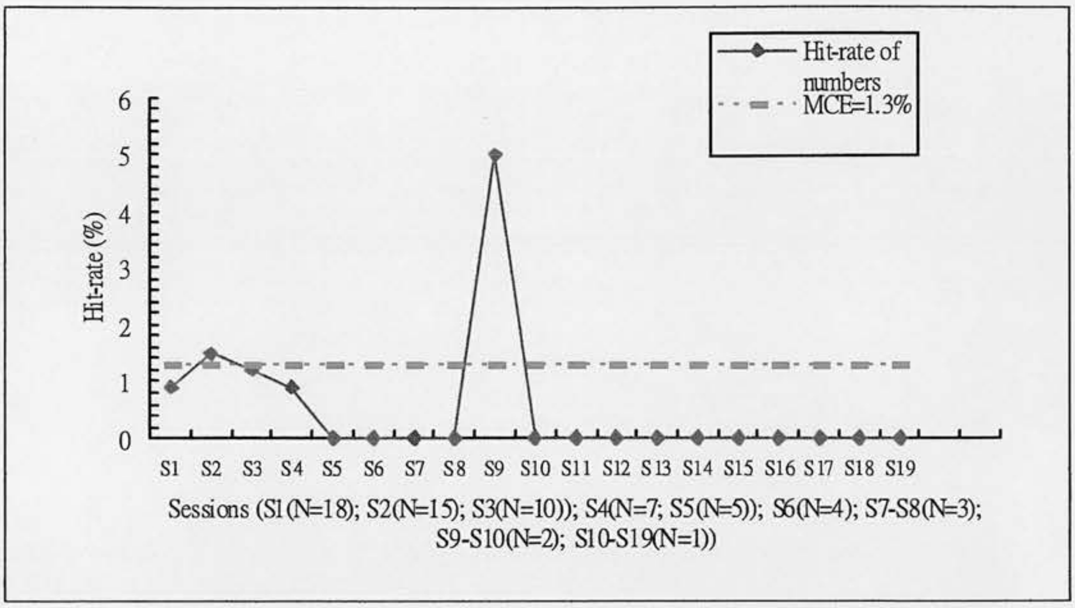


Figure 5-3. Across-session analysis of hit-rate of numbers

In view of the fact that no significant results were found, this in turn could not support the Hypotheses 3 and 4, though most of the participants (72%) reported seeing images of targets. Due to the fact that there was only one participant in later sessions and no obvious trends with increased trials, the planned analyses 5 and 6 were not performed. There was no significant relationship among rate of scoring and mental imagery, tactual experience and paranormal beliefs, as shown in Table 5-6.

Table 5-6 Correlations between imagery questions, tactual questions, beliefs in paranormal beliefs and hit- rate of colours, numbers and numbers with colours (N=18)

Questionnaire	Hit- rate of colours	Hit- rate of numbers	Hit- rate of numbers with colours
1. Imagery questions			
1.1 Easy to create a mental image of a familiar scene	.144	-.130	.140
1.2 The mental image is clearly seen	.147	-.206	-.306
1.3Perceive auditory components of a mentally imaged scene well	.179	-.277	-.393
1.4 Perceive olfactory gustatory components of a mentally imaged scene well	.416	-.029	-.031
1.5Perceive gustatory components of a mentally imaged scene well	.373	-.335	-.264
2.Tactual questions			
2.1Imagine feeling something well through touching	.071	-.108	.055
2.2 How many hours they use a keyboard per day	.013	-.307	.226
2.3Get a visual image when you touch something that you cannot see	-.192	-.186	.123
2.4 Good touch sensitivity	-.122	-.011	.044
3. Beliefs in paranormal			
3.1Belief in the existence of ESP	.040	-.387	.026
3.2 Any experience of telepathy	.049	-.126	.231
3.3Any experience of clairvoyance	.099	-.198	.220
3.4Any experience of precognition	-.432	.300	.284
3.5 Existence of psychokinesis	.249	-.419	.236

5.3 Discussion

The results do not support any of the proposed hypotheses, thus failing to replicate the finger-reading effect. This might show that finger-reading ability does not really exist. There was no significant relationship between any questionnaires and hit ratio for recognising colours, numbers and numbers with colours. This might be due to the non-significant results and a small sample size with only 18 participants in this study. It would be premature to conclude that the finger-reading ability does not exist on the basis of only this present study. More research is required.

Unexpectedly, most of participants (89%) reported that they could easily create a visual image of a familiar scene and 94% reported their mental imagery was clear. Many normal sighted adults have little or no mental imagery (Bartolomeo, 2002), as well as people who have cortical blindness, achromatopsia, visual agnosia, and hemispatial neglect (Pylyshyn, 2003). In addition, 61% reported perceiving auditory components of a mentally imaged scene; 44% reported perceiving olfactory components of a mentally imaged scene well; 39% perceived gustatory components of a mentally imaged scene well. Do most children really have such ability? The answer cannot be provided now, since, in fact, no study has given an account of this, and therefore more children need to be recruited in later studies to gather more data to answer this question.

How do we explain that most of the participants experienced visual images of targets but they were wrong? Based on the results, most of participants easily create a visual image. Visual representations of visual imagery are considered to "depict" objects instead of describing objects, revealing a picture-like reconstruction of the spatial geometry of objects (Kosslyn, 2005). Anticipating seeing an image leads to the priming of the representation of a target's object-properties in the brain. Neuroimaging studies of visual imagery indicate activation in the primary visual cortex (V1 or V2) (Ganis et al., 2001; Kosslyn et al., 1999; Kosslyn & Thompson, 2003; Kreiman, Koch, & Fried, 2000; Thompson, Kosslyn, Sukel, & Alpert, 2001), which is the part of the brain which first receives input from the eyes. This evidence supports the existence of a real image appearing in the participant's mind, which is termed as "seeing pictures with the mind's eye" (Kosslyn & Thompson, 2003). Visual experience might be created by one's will by means of retrieving from memory without perceiving any accurate information from the outside world. The author is inclined to think that experiencing visual images of wrong targets in this experiment are primarily mental images – in other words, just imagination.

In paranormal beliefs, 72% reported they believed in ESP and 39 % reported they believed in psychokinesis. One study reveals that 36% of the adult population reported they believed in ESP (Blackmore, 1984b), suggesting that children might be a group of believers in ESP. Twenty-eight percent of the participants reported they had experience of telepathy; 17 % reported they had experience of clairvoyance; 67 % reported they had experience of precognition. The result is higher than the statement that 10 to 15% of the adult population have had ESP experiences estimated by parapsychologists (Broughton, 1991). Three possible reasons might account for why children were more inclined to believe in ESP than adults. The first possible reason might be that children reported they experienced ESP experience more. As noted in Chapter 2, the second possible reason might be that children are inclined to seek attention or to please experimenters, resulting in reporting that were more inclined to believe in ESP than adults. Finally, children are generally considered to be more intuitive than adults (Drewes, 2001). Intuitive thinking is found to be positively correlated with paranormal beliefs (Aarnio & Lindeman, 2005). It is believed that ESP might especially occur in childhood (L. E. Rhine, 1965; Roll, 1997). More studies, such as further investigating those claimed psi abilities or accumulating more data from children, are needed.

If finger-reading as a manifestation of ESP really occurs, it is unlikely that the finger-reading effect involves tactile sensitivity. It is reasonable to see that there was no significantly relationship between the tactual problems and hitting rates. For this reason, as noted before, the impact of ignorance of using rating scale for the clarity of the images of unseen touch targets can be disregarded.

This study has the problem of "optional stopping", although the stopping was decided by all participants. That is, the number of trials in this study was not pre-specified, and in fact the number of trials varied quite a lot from one participant to another. The participants may have chosen to terminate the testing early, or to extend it to achieve an optimal performance. This flaw of optional stopping introduces statistical artefact that might bias the results of study. Given that no participants achieved a significant scoring, this concern can be disregarded. This flaw should be eliminated in the future. There are two strategies to avoid this problem– either to include in the analysis only those participants who completed the pre-specified number of trials (exactly that number), or to have someone who is blind to the participant's performance decide when to terminate the session.

5.4 Conclusions

The present study follows up Lee's promising finger-reading results under more stringent conditions. Overall, no significant results were found. There was no significant relationship between scoring and mental imagery, paranormal beliefs and tactual experience.

Based on Lee's results, the participants who showed significant results had taken part in an intensive training with at least four consecutive sessions (days), where each session was about two hours. A possible explanation for why the results did not show overall significance is that all participants failed to attend to a truly intensive training. Professor Si-Chen Lee (personal communication, January 21, 2006) suggested the finger-reading effect would be manifested via the intensive training. This assumption needs to be investigated.

According to Tart's ESP learning theory (Tart, 1966, 1975, 1977a, 1986; Tart et al., 1979), receiving trial-by-trial feedback immediately improves ESP performance only with "talented participants" who demonstrate psi ability. So another possible explanation might be that the unselected participants who did not show psi ability could not benefit from the training.

Taken together, in order to acquire maximum finger-reading results, the author suggests drawing on the concepts of Tart's ESP learning theory and Lee's intensive finger-reading training procedures. To utilise the concept of selecting possible talented participants, this procedure consists of three phases: a selection study (SS), a confirmation study (CS) and a training study (TS) (Honorton et al., 1971; Tart, 1966, 1977b; Tart et al., 1979). Professor Charles T. Tart (personal communication, January 28, 2006) and Dr. John Palmer (personal communication, February 3, 2006) considered the finger-reading studies following this three-stage methodology a good idea.

Regarding the mental images, it seems that children easily create them. If finger-reading is real, this gives rise to a very interesting question: "What is the relationship between mental imagery and the finger-reading effect, especially when experiencing the vivid screen in terms of transparent or opaque?" In addition, fifteen different types of visual images have been studied using the ganzfeld technique (Delanoy, 1986), though no type of mental imagery has been found to have a positive relationship with psi hitting. If certain categories or types of visual images are related to finger-reading ability, this information will be very useful for training participants in finger-reading ability. Further inquiry employing the imagery categories used by Delanoy and Lee may help parapsychologists to understand what categories of visual images relate to finger-reading ability.

Finally, although the finger-reading effect has not been found significant in this study, more research is needed. A study with pre-specified trials using selected potentially talented child participants receiving intensive finger-reading training would be desirable – an experiment which will be conducted in the next Chapter.

Chapter 6. Experiment 3: Finger-reading training -- Touching a two-digit number, using selected participants

Drawing on the concept of selecting possibly talented participants, the procedure in the present experiment[7] includes three phases: a selection study, a confirmation study and a training study. As noted in Chapter 2, some participants seemingly showed finger-reading ability after only 20 minutes of practice. In the present experiment, a selection study with ten trials and a confirmation study with twenty trials took the participants about three hours to complete. Based on Lee's finding that some participants seemingly showed finger-reading ability after only 20 minutes practice, the period of three hours for a selection study and a confirmation study would be plausibly expected to select some gifted participants from among a large sample. The detailed procedure will be described later.

If certain categories or types of visual images are related to finger-reading ability, this information will be very useful for training participants in finger-reading ability. Fifteen different types of visual images have been studied via the ganzfeld technique (Delanoy, 1986). These categories, divided into five groups, are:

Type of image:
1. interrupting an ongoing chain of thought
2. is the result of one image changing into another
3. developed into a recognizable image from an unclear one
4. appeared spontaneously

Duration: the image was
5. fleeting
6. persistent
7. recurrent

Clarity: the image was
8. undeveloped
9. detailed
10. had intense colour

[7] The main results of this chapter have been accepted by the Journal of Parapsychology for publication.

Content:
11. bizarre
12. related to personal memory or experience

Miscellaneous:
13. there was an auditory component
14. an impression of a sensation occurred – e.g. "I feel as if I'm floating".
15. the participant experienced an actual physical reaction to an image

The author suggests that a further two types of image should be included and two types of image 15 should be modified. First, the concept of a transparent or opaque screen based on Lee's findings (Tang et al., 2000) should be added. Next, based on the observation in Experiment 2, some participants seemed to close their eyes to touch, whilst some participants do not. The information of whether participants perform the finger-reading task with open eyes or closed eyes should be included. The image type regarding clarity should be changed. The clarity of the images of targets could be subjectively rated quantitatively by participants to provide useful information for analysis. As to the category of content, images of the exact targets should be included. With respect to a recurrent image, one practical question of "how many times do you see an image?" can be added to the recurrent image category.

Four types of images can be excluded. During finger-reading practice, the participants were required to wait for images of the targets. For this reason, interrupting a chain of thought and spontaneous image is less relevant to finger reading, which, therefore, should not be adopted. The image of an impression of a sensation which occurred should be ignored since it is apparently irrelevant to finger-reading experience. The last image of the participant experiencing an actual physical reaction to an image was not included because very few participants reported it in the previous study (Delanoy, 1986). The categories of content and miscellaneous should be included in the first category.

Now the new three groups of visual images are as follows.
Type of image:
1. With open eyes or closed eyes
2. Transparent or opaque image: A transparent image is like a mist, with a floating patch or pattern overlaying their field of vision, while an opaque screen is like a distinct form of imagery masking the normal visual image.
3. Developed from an undeveloped image: when a recognisable image develops from

an unrecognisable image; e. g. "I see something rather like red mist, oh, now I can see that it is a 77 in red."

4. Result of a transformation: when one image turns into another; e. g. "I see the number 17...then the number just became a number of 79."

5. Bizarre: an image which contains an unusual combination of elements; e. g. "I see a 77 in a red flower."

6. Personal memory or experience: an image which is related to a personal memory or a personal experience.

7. Auditory: an image which has an auditory content; e. g. "I hear a voice of 77 in red".

8. The same as for the targets: e. g. "I see a 77 in red on a piece of paper."

Duration:

9. Fleeting: a brief image which quickly appears and disappears
10. Persistent: an image which stays in the mind a while
11. Recurrent: an image which appears several times; how many times?

Clarity:

12. Participants subjectively rate images of targets, including, digits, words and their colours, if they experience images. Uses a 1-7 scale where: 1= Not clear at all, 7= As clear as normal vision.

6.1 Experiment 3: Touching a two-digit number directly using selected participants

This experiment was conducted between February 2006 and May 2006.

6.1.1 Hypotheses, exploratory questions and data analysis

This study was designed to test most of the formal hypotheses and exploratory questions mentioned in Chapter 5 for the training study. As selection and confirmation studies were exploratory in this experiment, no predictions were made.

Hypothesis 1 addresses the main concern of this experiment – participants would achieve a significant result and above-chance scoring at recognising numbers with colours would be elicited in the training study.

H1.Overall hitting of above-chance scoring of recognising numbers with colours would be significant in the training study.

Hypotheses 2 and 3 concern the existence of the visual experience, the appearance of a visual screen, and improved scoring after subjectively experiencing a visual screen.

H2. Participants with a significant result in the training study would have a visual experience followed by successful identification while touching targets, especially when seeing a transparent screen.

H3.Participants in the training study would have significantly improved scoring after seeing a screen while touching a target, performing better than children not reporting having seen a screen.

An important prediction of Tart's ESP learning theory was that there was a positive correlation between pre-training ESP talent in CS and improvement during TS (Tart et al., 1979). For this reason, Hypotheses 4 and 5 concern the prediction that participants who got high scores in the SS would get high scores in later performance (in the CS and TS) or participants who got high scores in the CS would get high scores in the TS.

H4. There was a positive relationship between participants who got high scores in the SS and people who got high scores in later performance (in the CS and TS).

H5. There was a positive relationship between participants who got high scores in the CS and people who got high scores in the TS.

Exploratory questions were: What percentage of children would achieve a significant result in the training study? What is the result of overall scoring of recognising numbers with colours in the training study? What is the result for hits of recognising numbers? What is the result for hits of recognising colours? What percentage of types of visual image would children report in the training study? Would children have similar types of image in the training study? What is the relationship among scoring and mental imagery, type of visual image during touching, paranormal beliefs and tactile experience in the training study? What is the appearance of visual experience followed by successful identification while touching targets in the training study? The data might suggest further exploratory questions.

The planned analyses in the training study were:

1. Overall hit scoring of each participant was analysed by means of a binomial, two-tailed test.
2. Overall hit scoring of all participants was analysed by means of a binomial, two-tailed test.
3. Overall hit scoring of all participants and each participant was analysed by means of the effect size, π (Rosenthal & Rubin, 1989), if overall hit scoring is significant indicated by binomial test.
4. Across sessions, hit rates for colours, numbers and numbers with colours was displayed by a graph.
5. The hit rates for colours, numbers and numbers with colours of all participants was examined for across-session hit rate of colours, numbers and numbers with colours by means of an ANOVA (repeated-measures design).
6. The hit rates for colours, numbers and numbers with colours of each participant was examined for across-session hit rate of colours, numbers and numbers with colours by means of an ANOVA.
7. The difference in scoring between participants reporting having seen a screen and participants before they have learnt to see a screen was analysed by means of a two-tailed t-test.
8. The difference in scoring between participants reporting having seen a screen and participants not reporting having seen a screen was analysed by means of a two-tailed t-test.
9. Positive relationships between participants who got high scores in the CS and people who got high scores in the TS was examined by means of Spearman correlation coefficients.
10. Histograms were used to see whether the frequency of each imagery type varied from each participant and within participants (across sessions).
11. Hitting rates, imagery questions, paranormal beliefs, touching questions, type of imagery, and background variables was examined by means of Spearman correlation coefficients.

6.1.2 Selection Study (SS)

The purpose of this study was to screen a large number of participants to find those who had possible talents in finger-reading ability. It took two months to complete the SS.

6.1.2.1 Method

6.1.2.1.1 Participants

2,200 child participants aged from six to thirteen had been invited by the author from the Hemei primary school in Taiwan. 1,771 joined in this experiment. 1,655 completed ten trials. They were aged from 6 to 13 (M=9.33; SD= 1.63), 836 boys and 819 girls. None of them had a history of nerve or brain injury, finger trauma, or learning disability (including dyslexia), and their finger pads were free of calluses. Participants who had diabetes were excluded, because of associated peripheral neuropathy. My supervisor wrote a letter (Appendix 13) to the principle of the Hemei primary school to get permission to put up a notice describing the experiment in the school, and possibly to give copies of the notice (Appendix 14) to teachers of classes in the appropriate age groups to send home with interested children to discuss with their parents. The informed parental consent form can be seen in Appendix 15. All of the children were tested in an isolated room in the Hemei primary school. The parents of child participants signed an informed consent form before the experiment. All experimental procedures were approved by the Ethics Committee of Psychology at Edinburgh University for the protection of human participants, including the procedures of the confirmation and training studies.

6.1.2.1.2 Material and Procedure

Child participants were asked to complete 10 trials. The stimuli were a two-digit number with a colour, which was the same as was used in Chapter 5. The author worked as an experimenter and a co-experimenter worked jointly to test all 1,771 participants in the different classrooms. The safeguards and procedure can be seen in Chapter 3.

The process began with warm-up practice. First of all, the experimenter turned the light off. Participants were required to sit and close their eyes and breathe deeply with a calm and peaceful mind for at least five minutes. The light was put back on. Then participants were required by the experimenter to practice "image making". The experimenter showed a red apple or other simple objects to the participants, who were asked to look at the apple very carefully and remember every detail of it. Then they closed their eyes to visualise the apple exactly as they perceived it. It was found in the author's previous trials that all children seemed able to perform this task. Once they can do this, they tried to visualise the apple changing its colour three or four times, i.e., through green, blue and black. Participants also saw a demonstration by the experimenter describing the "touch reading" phenomenon, such as how to identify the target.

Due to limited manpower and time, the author and a research assistant worked jointly to test all of the children in groups of around 30. The trial samples were prepared by a research assistant who did not participate in this experiment. The experimenter gave the co-experimenter one big envelope containing samples. Ten trial targets were folded twice bound by a rubber band and all were put on the participants' desks by the co-experimenter.

Participants were instructed by the experimenter to touch them in the drawers of their desks without seeing them. Participants were asked to focus on touch and to imagine that they can see the numbers while touching. There were no time restrictions and participants were free to use whatever scanning force and speed they chose to touch the targets. Each participant wrote down the final response on the recording sheet before taking out the item from the drawer. If participants got one or more hits in colour and number ($p<0.05$, binomial analysis, two-tailed), they were invited to join the next study.

Undoubtedly, sensory leakage was a problem in the study. One research assistant could not carefully observe each participant's responses and behaviour to rule out peeking. Although the target was folded twice to prevent seeing and peeking, a remote possibility was that the research assistant and participants might see a mark on the outside. Participants who have a significant result in this stage might have their result due to a chance based on only ten trials. These problems were dealt with in the training study. In addition, the result of the selection study would not be counted in the final result of training study.

6.1.3 Confirmation Study (CS)

The purpose of this study was to identify and remove those participants who score significantly in the SS by chance or peeking. The CS immediately followed the SS. It took three months to complete the CS.

6.1.3.1 Method

6.1.3.1.1 Participants

The author invited the participants who had a significant result in the SS to join this study. All of the children were tested in the same isolated room as was used in the SS phase.

6.1.3.1.2 Procedures and materials

The procedures and materials were the same as in Chapter 5. The author worked as an experimenter and a co-experimenter worked jointly to test all participants across twenty trials in the same room. The detailed barriers (bag, screen and video recorder) and experimental room can be seen in the Chapter 3. One experimenter and one co-experimenter stand each side of the screen (Figure 3-4). The general guideline for the positions of an experimenter, one co-experimenter and a video camera is that the frame of observation must include a clear view of the participant's hand, cuffs and the bag.

Among 20 trials, if participants get one or more hits in colour and number ($p<0.05$, binomial analysis, two-tailed), they were invited to join the next study. Because of the limited resources, each sample was not put into each envelope to save manpower and budget. The trial samples were prepared by a research assistant who did not participate in this experiment. Twenty trial targets were folded twice bound by a rubber band in a big envelope. Participants did not have a chance to see the samples.

The experimenter gave the co-experimenter one big envelope containing samples. The co-experimenter opened the sealed big envelope. Then, the co-experimenter took one sample from the envelope and put it in the black bag, and then closed the zippers. The rest of the samples were kept in the envelope by the experimenter until required. Thus, participants did not see any samples during this process. Participants were clearly informed of the meaning of randomization by the experimenter.

Next, participants put their hands into the two tight cuffs of the screen and the black bag. They were required by the experimenter to scan targets using their fingers. During the finger-reading training, the participants were required by the experimenter to focus on touch and to imagine that they can see the numbers while touching the target. They were told that there is a fold in the top left corner as a cue for them to touch the target exactly. There were no time restrictions and participants were free to use whatever scanning pressure and speed they choose. They were asked to inform the co-experimenter about whatever they saw and felt. They cannot take their hands out of the black bag during the touching procedure. Participants were told by the experimenter that pulling at the bags or cuffs was not allowed, and to avoid any unnecessary movement of their arms. They can only take their hands out of the black bag after they told the co-experimenter their final response. In the meantime, the co-experimenter and the experimenter recorded the participant's responses and response times.

After the participant finished the trial, the co-experimenter took out the item from the black bag and showed the number with its colour to the participant. Participants therefore got feedback. If participants wanted to have a break during the experiment, the co-experimenter sealed the big envelope containing the rest of samples and put it in another isolated room. The experimenter locked the room, so that no one can access the room and the samples.

Possible sensory leakage might be that the experimenter and the co-experimenter might see the mark from the outside of the samples. This possible problem can be solved in the training study. The result of confirmation study would not be included in the final results.

6.1.4 Training Study (TS)

Based on Tart's and Lee's ideas, this study was to investigate improvement in scoring by providing participants with immediate trial-by-trial feedback.

6.1.4.1 Method

6.1.4.1.1 Participants

The author intended to invite the participants who had a significant result in the CS to join this study. As will be noted later, no children at all had a significant result in the CS. For this reason, no one joined in the TS.

6.1.4.1.2 Material and procedure

It was intended that, had any of the participants moved on from the CS phase into the TS phase, those participants would have been tested in 80 trials individually, using the same procedures, materials and questionnaires as those used in Chapter 5. A questionnaire concerning the twelve types of image already mentioned would also have been included (see Appendix 16).

The experimenter gave the co-experimenter one big envelope containing a plastic bag containing twenty small envelopes. The co-experimenter opened the sealed big envelope. Then, the co-experimenter took one small envelope from the plastic bag and put it in the black bag, and then closed the zippers. The rest of the small envelopes were kept in the plastic bag by the experimenter until required. Thus, participants did not see any envelopes during this process. Participants were clearly informed of the meaning of randomization by the experimenter.

Next, participants put their hands into the two tight cuffs of the screen and the black bag. They were required by the experimenter to open the sealed envelope to take out a sample to scan targets using their fingers. Participants were taught by the experimenter to tear the very end of right or left side of the envelope to take the target paper out, since the target paper was in middle of the envelope.

During the finger-reading training, the participants were required by the experimenter to focus on touch and to imagine that they can see the numbers while touching the target. They were told that there is a fold in the top left corner as a cue for them to touch the target exactly. There were no time restrictions and participants were free to use whatever scanning pressure and speed they choose. They were asked to inform the co-experimenter about whatever they saw and felt. They cannot take their hands out of the black bag during the touching procedure. Participants were told by the experimenter that pulling at the bags or cuffs was not allowed, and to avoid any unnecessary movement of their arms. They can only take their hands out of the black bag after they told the co-experimenter their final response. In the meantime, the co-experimenter and the experimenter recorded the participant's responses and response times.

After the participant finished the trial, the co-experimenter took out the item from the black bag and showed the number with its colour to the participant. Participants therefore got feedback. If participants wanted to have a break during the experiment, the co-experimenter sealed the big envelope containing a plastic bag containing the rest of samples and put it in another isolated room. The experimenter locked the room, so that no one can access the room and the samples.

6.2 Results and discussion

Participants' responses, including the experimenter's record, the co-experimenter's record and the original data were double-checked by an independent researcher. In the selection study, 820 participants among 1655 participants scored one or more hits of recognition of a two-digit number with a colour, as seen in Table 6-1.

Table 6-1 Participants' hits of numbers of recognition of a two-digit number with a colour (N=820)

Hits of numbers	Number of participants
1	319
2	164
3	112
4	64
5	61
6	34
7	25
8	17
9	14
10	10

The author invited all 820 to the CS. Seven hundred and twenty eight have joined in the CS. The author and a research assistant worked jointly to test all 728 participants individually across twenty trials. They were aged from 6 to 13 (M=9.12; SD= 1.52), 350 boys and 378 girls. None of them have scored above one hit of recognition of numbers with colours, including one hit. For this reason, no one has joined in the TS.

A surprising result of the selection study shows that fully 820 children attained a significant result. One of the possible explanations for this remarkable result might be that possible sensory leakage led to peeking. Professor Si-Chen Lee (personal communication, April 22, 2006) pointed out that another possible explanation might be the effect of different environmental settings. Especially, in the CS, a screen was added. Based on the over 10-year finger-reading training experience, Lee believed that the changed settings would take more time for children to get used to them. The reasons why this issue of different settings might decrease participants' performance are still unclear. Indeed, many children subjectively reported that the screen increased the difficulty of recognising targets. Some of them reported that it was more difficult to have visual experiences while touching the targets. One of the best solutions to avoid this defect caused by different settings is to use congruent settings in different stages of the finger-reading study.

The results do not support any of the proposed hypotheses, revealing an unsuccessful replication of the finger-reading effect. This might reveal that finger-reading ability is not in actual fact real. Since scientists place high value on the "replication", it would be premature to conclude that finger-reading ability does not exist on the basis of this present study. More research is necessary.

6.3 Conclusions

The present study follows up Lee's promising finger-reading results to select possibly talented children. Overall, no significant results were discovered.

This study failed in its objective of selecting potential children to acquire finger-reading ability and then to give them an intensive training. Another possible explanation for why the results did not show overall significance is that none of the participants was talented. For instance, 1% of unselected adult participants performed successfully in remote viewing tasks (Utts, 1995). Ryzl (1966) reported 10% of unselected adult participants attained some types of ESP after training. This might be chiefly due to the fact that ESP is elusive and weak.

It would seem, then, that these results clash with findings previously reported by Lee. However, according to Lee's results, the participants who demonstrated significant results had taken part in intensive training for at least four consecutive sessions (days), where each session was about two hours. In addition, Lee suggested the finger-reading effect would be manifested via intensive training with more than four sessions (personal communication, April 22, 2006) if no talented participants are found. In fact, it might take over a hundred hours to train finger-reading ability (Lee, 1998). It is necessary to explore this issue of the required period of training. Due to the uncertainty of ESP, there is no way to objectively define when to stop training if no progress is being made, and researchers might just have to make an arbitrary decision. This should be a cutoff that researchers use consistently, so the procedure is defined for someone who might want to replicate the study.

Because of the uncertainty of ESP, we still do not have a clear map that how ESP can be trained. Proposed ESP learning processes need to be established to provide testable assumptions. This issue will be discussed in Chapter 7.

With regard to possible peeking or sensory leakage involved in the selection and confirmation study, the author suggests the three-phase study should use the same procedure to avoid them, if required manpower and resource is provided. Another advantage is that the issue of changed settings leading to decreased performance will be ruled out.

Overall, then, the findings from this study demonstrate that if a study of finger-reading is conducted using appropriate levels of experimental control, then the findings reported by researchers such as Lee are not confirmed. This presents support for the claim that finger-reading ability does not exist. However, authors such as Lee have argued that the training required to develop such an ability may involve very lengthy and intensive procedures. It is, then, possible that the training received by participants in the present study was not intensive enough to generate this ability. To this extent, those who support the notion of finger-reading might argue that further research is required in this area. This indicates that a well-designed ESP learning study with pre-specified training procedures in which participants receive appropriate levels of finger-reading training may prove useful in future research.

Chapter 7. Discussion and conclusions

This thesis presents a modified finger-reading training paradigm under stringent conditions. The author proposed this standard paradigm in the hope of attracting more researchers and resources to use its safeguards and investigate the finger-reading effect, including the author's investigation. In addition, the author suggests that methodological considerations discussed in this thesis can be used for later tactile acuity studies.

The first experiment conducted for this thesis was designed to determine the limits of tactile relief recognition. The results indicate mean threshold of eight digits is between 0.05 mm and zero. The performance of recognising eight digits with all six elevations was significantly lower in the child group compared to the adult group. Poorer tactile relief acuity in children may represent an immature tactile mechanism. Touching targets with zero elevation is suggested for use in the later finger-reading experiments with a view to ruling out possible tactile cue of raised targets.

No significant overall scoring was observed in either of the two finger-reading studies conducted for this thesis. Thus, these studies seem to indicate that finger-reading ability does not exist. This seems to contradict the findings reported in Lee's studies (Lee, 1998, 2002, 2003; Lee & Chang, 2001; Lee et al., 2000; Lee et al., 2002). However, in a context where some researchers (Carpenter, 2004, 2005; Palmer, 2003; Walach & Schmidt, 2005) have argued that ESP phenomena are real, the following discussion addresses some possible alternative explanations for the present study's unsuccessful replication of Lee's findings. Following this discussion, the present chapter then moves on to consider the question of how to train people in the use of ESP if it does exist. A three-stage testable ESP training model is proposed to guide future research[8].

7.1 Possible explanations for the unsuccessful replication

7.1.1 Talented participants not found

Based on Tart's ESP learning theory, only talented participants benefited from feedback interventions. One possible explanation might be that no participants in the studies of Chapters 5 and 6 had psi ability, so that none could benefit from the training or practice.

[8]This ESP training model was submitted to the Journal of the Society for Psychical research on 25^{th} January 2008 and now is under review.

7.1.2 Training period might not be enough

If no talented participants are found, it might take hundreds of hours to train finger-reading ability (Lee, 1998), suggesting that it might take days or years to learn finger reading. Most of the participants' training period in Chapters 5 and 6 did not exceed four hours on the average. One of the possible reasons for the failed replication of the finger-reading effect might be the short-term training period. Nevertheless, there is a tension between the claim that it might take years and other claims that it can take only 20 minutes. We have insufficient evidence of how much time is exactly needed for the finger-reading training. Similarly, other ESP abilities face this question. For example, though it is unclear how much time is needed to train remote viewing (Utts, 1995), it is claimed that participants performed excellently in remote viewing after a several-year period of training (Puthoff & Targ, 1976). Variations in the required training period might depend on different ESP tasks used.

7.1.3 Why giving feedback did not work

Tart (1975) pointed out that only "talented participants" who demonstrate ESP abilities will benefit from immediate feedback. This idea is considered unestablished for ESP learning, such as remote viewing learning (Utts, 1995). Giving immediate feedback did not improve ESP (Vitulli, 1983). Similarly, an inconsistent result of giving feedback can be observed in normal learning. The effects of feedback interventions on normal performance has improved performance on average in a meta-analysis of studies (131 papers, 23,663 observations, including one ESP study with a negative result), although about one third of cases of giving feedback even led to lower performance (Kluger & DeNisi, 1996). How do we resolve this confused topic of giving feedback or not giving feedback on ESP training?

The concept of giving immediate feedback draws on the law of effect (Thorndike, 1927), according to which rewarding feedback interventions reinforces learning and performance. Based on this law, in the normal learning process, positive feedback interventions are commonly used as a reinforcer for the learning process. A reinforcer refers to a rewarding stimulus that increases the frequency of a response. Specifically, the feedback serves as a function of "feedback standard comparisons" (Kluger & DeNisi, 1996), referring to changing behaviour being regulated by feedback standard comparisons. Feedback is used in comparison to goals or standards, providing feedback of the discrepancy between standards and performance. There is motivation to reduce the discrepancy and this plays an important role in reinforcing learning (Seitz & Watanabe, 2005) resulting in habituation (McSweeney & Swindell, 1999).

In addition, this evaluation process of comparing goals and behaviour provides information for a new decision of whether to keep trying or to quit.

There are three possible explanations as to why giving immediate feedback can be negative. First, feedback might not be given with appropriate timing. According to the concept of feedback standard comparisons described above, one of the purposes of giving feedback with correct timing is to create an appropriate dissonance between the feedback and behavioural goals. The other purpose is to afford sufficient information for a decision about whether to try further or not. Participants might reject the feedback message or standards when it is impossible for participants to reduce the dissonance (Kluger & DeNisi, 1996). Especially, if feedback is that the goal is impossible to achieve, participants might decide to give up. During ESP performance, including experiencing implicit psi (Stanford, 1974a, 1974b, 1990), participants seemingly perceived information about targets in their minds and thinking via ESP perception. Implicit psi refers to psi occurring with no intention to produce it or awareness that it is occurring. If a participant does not have any experiences of perceived information about targets (the goal), the goal is too difficult to reach.

The second explanation is this. In normal learning, giving feedback leads to decreased performance by participants when they focused on themselves rather than on the tasks (Kluger & DeNisi, 1996). ESP performance is suggested to occur when the mind is quiet, as will be discussed in the next section. According to this premise, any unnecessary cognitive activities, including too much focusing on oneself, should be excluded in order to reduce internal somatic noise.

Last, the effect of giving immediate feedback on ESP performance might cause satisfaction, frustration or arousal. The effects of negative and positive mood might have an impact on a relaxed mind. Arousal will lead to possible cognitive activities, such as attention (Kluger & DeNisi, 1996).

In fact, parapsychology is in a difficult situation due to the lack of a repeatable experiment of strong manifestations of *psi* (Alcock, 2003; Milton & Wiseman, 1999, 2001). One of the solutions is to learn how ESP can be trained so that we can have reliable ESP results. If ESP is trainable, many questions remain, in addition to those mentioned above. A central issue is how do subjects know *what to learn* (Stanford, 1977a)? For this reason, an ESP training model is needed to answer these questions. The construction of an appropriate theoretical ESP training process will be important to examine whether the concepts employed can be sufficiently operationalized to enable a scientific test of the assumptions for the future study.

7.2 A proposed ESP training model

7.2.1 A premise of ESP training—the brain's cortex reacts to ESP signals

Adopting Tart's assumption that ESP is trainable, ESP performance can be regarded as a learned ability. Thus, one biological assumption is that ESP sensory input can be processed by the brain. Under this premise, ESP perception can take place and then lead to the possibility of ESP learning. ESP may be taught by way of a specific training procedure. Note that an old mystery of how we perceive ESP information still has not been resolved, and this issue will not be discussed in this thesis.

7.2.2 A three-stage ESP training model

To explain the whole training process, the different stages are displayed summarily as a flowchart in Figure 7-1. Three steps should be followed and need to be completed to achieve success. This ESP training model presumes that participants do not show any ESP abilities at the beginning. However, it is claimed that talented participants showing ESP abilities might have been successfully selected via selection and confirmation procedures (Tart, 1966, 1977c; Tart et al., 1979). Talented participants meet the requirements of the first two stages of the proposed ESP training model without receiving the first two stages of ESP training.

Stage	Feedback
Before training: Accessing participant's training needs.	No
First stage Attain a quiet or drowsy state of consciousness. ↓	No
Second stage Waiting for visual images, feeling, intuition, or thoughts of targets. ↓	No, mere exposure of ESP targets.
Third stage Experiencing visual images, feeling, intuition, or thoughts of target.	Yes, feedback acts as a reinforcer.

Figure 7-1 Three- stage ESP training process

Before and during training, the training needs should be addressed by identifying a participant specification and tasks and skill required. The training needs can help the trainer to develop a suitable training program (Brown, 2002). Tart contended that ten factors will be positively related with ESP training:

> (1) high (not too high) motivation, (2) high general learning ability, (3) absence of resistances to psi, (4) good ability to discriminate contents of the experiential field, (5) good ability to separate experience-as-perceived from experience-as-interpreted, (6) good memory skills, (7) ability to quiet one's mind, (8) nonattachment, ability to drop strategies that are not adaptive in spite of emotional investment in them, (9) avoid guessing what has just come up as the previous target, and (10) ability to ignore sensory distractions. (Tart, 1977b, p.405)

It is well to access and remind participants of these ten factors before and during ESP training if necessary. To minimize the fear of psi, four strategies of cognitive/affective acknowledgment, learning adaptive coping skills, accepting responsibility, and personal growth have been discussed elsewhere (Tart, 1984). The rest of training needs will be included in later sections.

7.2.2.1 The first stage of ESP training

As noted in Chapter 2, ESP performance occurs best in a quiet state of consciousness. On the basis of the findings of the EEG and ESP performance, the author suggests a modified operational indicator of a quiet or drowsy mind as brain waves in terms of α, delta and theta. It is suggested that further ESP studies should use the same criterion. Additionally, a quiet state of consciousness is often reported as "a deep sense of calm, perceptual clarity, heightened awareness of the sensory information, a shift in the relationship to thoughts or feelings and a slowing of mind's internal dialogue" (Cahn & Polich, 2006). This subjective report can be used as a tool to evaluate participants' quality of a quiet state of consciousness.

According to Cahn and Polich's review study (Cahn & Polich, 2006), meditation practices, including Qigong, Yoga, autogenic training and Zen, are a good method to induce a quiet mental state with α brain waves or below, probably at frontal-central locations. Other methods are hypnosis, Ganzfeld technique, relaxation, rhythm-induced trance or biofeedback (Rao & Palmer, 1987; Vaitl et al., 2005).

It might take participants years to skilfully attain a quiet state of consciousness via meditation practice. To save training time, two strategies are suggested. One is to employ available participants who have practiced meditation for years. The second method is to use hypnosis, dreaming, Ganzfeld, relaxation, rhythm-induced trance, or biofeedback to induce in participants a quiet or drowsy state of consciousness.

During ESP training, participants might develop cognitive strategies such as storing previous targets in memory (Ertel, 2005; Tart, 1977b). This strategy of storing previous targets in memory or similar cognitive strategies should not be allowed. The reason is that a quiet state of consciousness is of importance to ESP performance. Cognitive activity increases brain activity towards the gamma (30-100Hz) ranges (Fitzgibbon, Pope, Mackenzie, Clark, & Willoughby, 2004). Ideally, only the strategy of attempting to be in a quiet and open mind should be permitted. However, the decision-making phase of ESP tasks, such as deciding given experience of ESP targets, is inevitable in the third stage of ESP training as well as the elaboration of feedback and storing useful strategies.

7.2.2.2 The second stage of ESP training

As a broad definition, consciousness refers to "the subjective awareness of momentary experience interpreted in the context of personal memory and personal state" (John, 2003). For instance, when you are asked the colour of a red apple, you consciously answer 'red.' On the other hand, using a strict definition, in fact, you cannot tell what and how exactly you decide the red colour from the actions of the brain (Crick & Koch, 2003), suggesting an unconscious process. In this thesis, the broad definition of consciousness is used.

ESP has been suggested to be an ability by which one can perceive a flow of faint and weak information from a variety of unknown sources, resulting in a meaningful integration (Roll & Persinger, 1998; Schmeidler, 1991; P. Stevens, 2002). Clearly, due to the purported characteristic of ESP information that it involves information which is below normal thresholds of perception, ESP perception has been claimed to be a preconscious phenomenon (Broughton, 2006; Carpenter, 2004; Schmeidler, 1986, 1991; Stanford, 1974a, 1990; P. Stevens, 2002; S. Wilson, 2002; S. Wilson, Morris, Tiliopoulos, & Pronto, 2004). Of course, everyday perception may also occur in a pre-conscious fashion, in that one may gain information from a perceptual source even though one is not consciously aware of receiving that information. Moreover, in both the ESP case and the everyday perception case, the product of that perception, such as an understanding or a mental representation, may well be something of which the perceiver becomes consciously aware.

Normal perceptual learning shares one important similarity with the nature of the stimulus in ESP learning, namely that participants sometimes have no conscious target-relevant thoughts. Priming studies show that perception can occur without awareness. Perceptual learning improves without feedback, merely with exposure to repeated stimuli which are perceptually invisible over thousands of trials for hundreds of hours, no matter whether attention is focused on the tasks or not (Seitz & Watanabe, 2005; Tsodyks & Gilbert, 2004). For example, in Watanabe's study (Watanabe, Nanez, & Sasaki, 2001), participants were repeatedly presented with a background motion signal whose direction was perceptually invisible, termed a perceptual priming effect (Wiggs & Martin, 1998). Improved performance for the signal's direction was observed. Watanabe, *et al.* (2001) believe that the human brain is capable of responding to certain stimuli in terms of mere exposure. If this assumption is acceptable, it is logical to infer that ESP learning can occur with large exposure to ESP tasks. Still, the assumption of Stage two ESP training needs to be empirically verified.

Picturing targets has been widely used to help generate ESP abilities (Blackmore & Rose, 1997; George, 1981). For instance, participants were asked to image the targets in ESP tasks (Blackmore & Rose, 1997; George, 1982; Honorton, 1975; Honorton et al., 1974; Price, 1973; R. Schechter et al., 1975) or Ganzfeld technique (Palmer, 2003). Other non-visual ways to manifest ESP are feeling (Broughton, 2002; Stanford, 1990; Tart, 1977b), intuition (Broughton, 2006; Broughton & Bourgeois, 2001; Irwin, 1994), or thoughts (Stanford, 1990; Tart, 1977b) of targets.

In this stage, the concept of the training is similar to White's "waiting technique" (White, 1964), Tart's guessing stage (Tart, 1977a) and Ryzl's induction of ESP (Ryzl, 1966), participants wait for responses of a target's image, feeling, intuition or thoughts to enter consciousness, which is the third stage. This waiting stage is unconscious in that participants just concentrate on waiting for the images, feeling, intuition or thoughts of targets.

This stage might take a certain amount of time for participants to get through, when participants might feel uncomfortable not to receive any visual images, or non-visual forms of targets for a long time. In view of this consideration, participants are encouraged to wait patiently and expect to experience visual images or non-visual forms of targets eventually during this stage. Success-related expectations could be seen in the sheep-goat effect (Schmeidler, 1952; Thalbourne, 1981). The sheep group (who believed in the possibility of ESP) had a better ESP score than the goat group (who did not believe in the possibility of ESP) in a meta-analysis (Lawrence, 1998). Expectation might tend to make appropriate response occur, which, in turn, leads participants to be more willing to wait passively for images or non-visual forms of targets, thereby reducing the signal-noise ratio.

7.2.2.3 The third stage of ESP training

Visual images, feeling, intuition or thoughts of the targets refers to three different phenomena: the first one is images, feeling, intuition or thoughts of the wrong targets; the second one is images, feeling, intuition or thoughts containing part of targets; the final one is vivid images, feeling, intuition or thoughts of the right targets. The author suggests that feedback interventions should be implemented in this stage, especially for the second and third categories of visual image, feeling, intuition or thoughts.

The purpose of providing feedback is to teach participants to distinguish ESP visual images, feeling, intuition or thoughts from other mental imagery, feeling, intuition or thoughts In practice, participants will be taught to use feedback to correct their responses, especially when their images, feeling, intuition or thoughts contain part of targets. They would learn that certain kinds of internal experiences would be associated with missing, almost-hitting or hitting, so they might learn to respond accurately when they find a way to sharpen finer discriminations. Successful ESP-task performance with feedback may help participants to memorize useful strategies and extinguish the use of the cognitive strategies, such as storing previous targets or similar strategies. Feedback also works as a reinforcer in the last two categories, though this does not apply when images, feeling, intuition or thoughts are of the wrong targets.

Once this ability is attained, drawing on the concept from Ryzl (1962, 1966), participants can be presented with more difficult and complex tasks. To increase the difficulty of tasks, accompanying the more familiar visual images, feeling, intuition or thoughts with the right targets is suggested. A good example is found in the finger-reading studies. The simplest task used was a two-digit number with a colour, and a more difficult task used was a Chinese character with a colour or an English word with a colour.

Altogether, the author suggests that participants can only benefit from this training process when they meet two important criteria. One is that participants can attain a quiet or drowsy mind in terms of α, theta and delta EEG waves. The other criterion is that participants have part or the whole of the right targets while demonstrating ESP abilities.

7.3 Concluding remarks

An attempt was made to develop a well-controlled paradigm of finger-reading training using more stringent controls. One study conducted for assessing the limits of tactual recognition of digits, participated in by 24 children and 24 adults, revealed that mean threshold of eight digits is between 0.05 mm and zero. The mean threshold of nine digits ranging from 0.05 mm to zero could be further examined. Children showed inferior recognition of raised digits, especially in recognizing digits requiring fine spatial resolution, such as 2, 3, 4, 5, 6 and 8. Touch samples with a zero elevation were suggested for later finger-reading studies to entirely eliminate the tactile explanation for the finger-reading effect. Two finger- reading studies were conducted for this thesis. The first study involved 18 children. No evidence was forthcoming that the participants had learned the finger-reading ability via the feedback intervention. The second study involving 1,655 children failed to select possibly talented children. Although no overall significant display of finger-reading ability was observed, the need for further investigation of the finger-reading effect is stated.

The author has raised possible explanations for the lack of overall significant finger-reading hitting earlier in the Chapter. Taken together, the author proposes a three-stage ESP learning model of ESP learning. If it occurs, ESP learning can be regarded as involving reaction to ESP signals, suggesting a three-stage testable model of ESP learning. (1) Participants should attain a quiet or drowsy mind by ways of meditation practice, hypnosis, Ganzfeld technique, relaxation, rhythm-induced trance or biofeedback. (2) Participants need to make efforts to wait for experience of targets with an open and quiet mind. With exposure of ESP targets, subjects may unconsciously become better at identifying and distinguishing a variety of ESP information. (3) Participants will hopefully experience images, feeling, intuition, or thoughts of targets in whole or part. Feedback interventions are only envisaged to work effectively at this stage. To test this training model, investigators can choose one type of ESP performance to run this ESP training model.

Some basic but important questions remain. One might ask the following questions. How much time is enough for the brain to respond to ESP tasks in the second stage?

How much time is enough for a participant to learn ESP? How much time is needed in each stage? There are no ready answers for these questions now. We have insufficient evidence.

Can all participants learn ESP? Tart (1977b) believed that only some participants improve their ESP performance after training. Tart also speculated that only participants who have ESP abilities will gain 5 to 20 % ESP from trial-by-trail feedback (Tart, 1977c). The empirical results reveal a wide range in the percentage of unselected participants who demonstrate successful ESP performance. 1% of unselected adult participants performed successfully in remote viewing tasks (Utts, 1995). Ryzl (1966) reported 10% of unselected adult participants attained some forms of ESP after training. 24% of unselected child participants seemingly performed significantly after finger-reading training. More research is needed to understand these questions.

ESP probably occurs best with low cortical waves on the EEG. Note that this may only apply to the adult population. At ten years old children show a dominant maximum rhythm value of 10Hz. It is not certain that children have a truly quiet mind compared to adults. But this might be one reason accounting for the negative relation between ESP performance and aging (Bourgeois & Palmer, 2002; Shargal, 1987; Spinelli, 1977; Van Busschhach, 1959).

In summary, although the overall finger-reading results do not support the existence of finger-reading ability, this does not mean that the finger-reading does not exist. Indeed, a major challenge for parapsychology research lies in the elusive evidence of ESP. A testable model of the ESP training process, involving three stages, was proposed. The proposed studies should test this ESP training model, including finger-reading studies. If ESP is real, two major problems remain. The first is that an underlying mechanism for ESP perception at the initial perceptual stage has not been fully proposed and the mode of transduction for paranormal information remains unknown. Secondly, in later ESP information processing, experiencing a visual image of a target seems to play an important role in ESP performance, as is seemingly shown by its significant correlation with correct recognition of targets. Little is known about how participants generate mentation of targets when performing ESP tasks. Within the broad field of science, the study of ESP might contribute to our knowledge of brain-environment relationships or interaction. The goals are still a long way down the road, and this thesis has attempted to take a step in the direction of exploring the elusive ESP.

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Appendices

Appendix 1: "Do human fingers "see"? -- "Finger-reading" studies in the East and West" as published in the European Journal of Parapsychology 2005

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Do Human Fingers "See"? — "Finger-Reading" Studies in the East and West

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Abstract

The "finger-reading" effect refers to successful touch identification of apparently flat targets on paper, where the participant is unable to see, or feel, any normal sensory cues to aid touch identification. Studies of this have been running for over 10 years in Taiwan. A quarter of children, after finger-reading training, appeared to be able to determine the identity of targets by means of directly touching a flat target varying in four different colours printed by an ink printer on paper. In the West, one study indicates that the fingers might read printing on paper without sight, while six studies find that fingers alone can discriminate colours on paper. However, a discussion of methodological issues follows, which points out the deficiency of well-controlled conditions in all the finger-reading studies reviewed. This leads to a conclusion that fraud has not been entirely ruled out – suggesting unreliable finger-reading results. In addition, this finger-reading effect has never been replicated. It is thus not safe to assume that exceptional abilities were in fact successfully measured. It is suggested that finger-reading needs to be further explored under stringent conditions, especially in children.

Introduction

Recently, attempts have been made to explore possible exceptional human abilities in Chinese societies. Si-Chen Lee, a professor of the

Correspondence details: Yung-Jong Shiah, Psychology Department, The University of Edinburgh, Edinburgh, Scotland, EH8 9JZ, United Kingdom. Email: s0239482@sms.ed.ac.uk. This paper is dedicated to Professor Robert L. Morris, the first author's late supervisor, who sadly died before publication.

Electrical Engineering Department at National Taiwan University and also the President of the most prestigious university in Taiwan, began to focus on finger reading from 1993 by way of a developed training paradigm. The first author was a member of his research team from 2000 to 2002. Following this, since 2003, the first author has studied at the Koestler Parapsychology Unit to learn about applying more rigorous scientific methodology to the exploration of exceptional human abilities, with a view to looking at possible explanations for the finger-reading effect.

A quarter of children, after finger-reading training, appeared to be able to determine the identity of targets by means of directly touching a two-digit number or a complex character varying in four different colours printed by an ink printer on paper. Some Chinese children seemed able to do this when other senses such as vision were ruled out. This "touch" effect has also been reported occasionally in Western experiments for more than a century. According to Novomeysky (1965), the first report of finger reading was published in Russian scientific literature in 1898. Since then, several studies were conducted to explore this effect. The results of Western studies apparently showed positive results. However, poor experimental design was used in most of the studies (Gardner, 1996). In addition, many of the participants who claimed to have this ability were found to be cheating e.g., peeking at targets (Gardner, 1966). The last Western study of finger reading was undertaken in 1992. Since then, no further research about finger-reading effect has been conducted in the West.

In fact, the finger-reading effect is also subject to criticism in Taiwan (Du, 2005). Does finger-reading ability really exist? Were the successful studies merely replicating errors and were they open to fraud? Could it just be an example of a performance using tactile cues? Before addressing those questions, we had better take a look at finger-reading studies in the East and the West. In what follows, finger-reading studies in the East and West will be reviewed and their limitations will be scrutinized. Future research will be suggested.

Studies of "finger reading" in Chinese society

On 11th Mach 1979, a boy aged 12 was reported by the Sichuan Daily in mainland China as seemingly possessing an "ear reading" capability, i.e. he was able to recognise characters written on a piece of paper screwed into a ball and put into his ear (Chien, 1981; Eisenberg, 1985; Gardner, 1996). Since then, hundreds of Chinese children have been reported as appearing to possess this ability. Sometimes a folded paper involving Chinese characters was placed into children's hands or armpits. One of the more recurrent claims of possession of exceptional ability was for a finger-reading capability (Lee, 1998; Wang et al., 1989). Empirically, it was further reported that this ability could be induced by intensive training. For example, out of forty children of ages ranging from five to fourteen, 15 appeared to show this touch effect after between three and ten training sessions (Chen et al., 1989). In this training programme, children were instructed to use their fingers directly to touch a paper with written Chinese characters. It was even claimed that children seemed able to read characters within folded paper after more training. The children reported that the targets seemed to appear in their minds as a real visual image even when other senses, such as vision, were ruled out. The researchers assumed this to be a demonstration of something like extra-sensory perception (ESP) (Lo et al., 1989; Shao et al., 1982; Tien, 1994; Wang et al., 1989). ESP is a general term used for all paranormal abilities that cannot be explained by "rational" terms (Irwin, 2004).

This finger-reading effect caught the attention of Si-Chen Lee. He gathered a research team to study this touch effect and developed a four-days-a-week, two-hour finger-reading programme to study these phenomena in Taiwan from 1993 onwards (Lee, 1998, 1999, 2002, 2003; Lee & Chang, 2001; Lee, Chen, & Tang, 2000; Lee, Tang, & Kuo, 2004; Tang, Lee, & Hsu, 2000). Briefly, the research team conducted a variety of training and testing procedures, and found that children, aged between seven and thirteen, were the easiest to train. Si-Chen Lee trained adults at first as well, but they seemed to benefit little from this training process and failed to show any positive results. It appeared to be very hard for adults to learn how to visualise targets during the training process.

The training procedures can be illustrated briefly as follows: First, the children were given imagery exercises. The children were trained by letting them touch a paper directly which bore a two-digit number or a complex character printed in four different colours from an ink printer. This training included a "dark" condition in which the paper with its character was put into a dark bag where it could not be seen. Then they were asked to imagine that they could see the numbers, characters or words while touching them. The children were encouraged to practise touching and visual imagery during this training process. The procedural training details will be covered and discussed later.

216 participants, aged seven to thirteen, were recruited from different elementary schools during the years 1996 to 2004. The average success rate at recognition (by $p < .05$ criterion) by means of directly touching an unseen paper with a two-digit number or a complex character varying in four different colours was approximately 24% (41 out of the 173 participants who went through the whole training programme). The dropout rate was about 20% (43 participants). The major reason for leaving the training programme was that the children felt the programme was somewhat tedious and time-consuming.

The children for whom the techniques seemed to be successful reported that visual experiences had accompanied their successful trials. They reported visual images appearing as if from the real world. They reported seeing a "transparent screen" like a mist, with a floating patch or pattern overlaying their field of vision. Some of the children experienced the coloured targets as a distinct form of imagery like an "opaque screen" masking the normal visual image. The quality of the screen reported by participants seems important for this touch effect; for example, children appeared to recognise easily complex characters or other complex symbols after seeing an opaque screen. The experience of this opaque screen in the mind correlated highly with correct recognition. It might be trained by touching a complex character, producing a more complex visual image display in the children's minds. The shortest training time was only 20 minutes.

Studies of "finger reading" in Western society

Novomeysky (1965) conducted a study employing 80 participants and found that participants distinguished well between colours presented in pairs just by touching, without seeing them. After two or three weeks of exercises, one-sixth of participants learned to recognise five to seven colours just by touching paper. In 1919, the finger-reading effect was investigated by the French novelist, poet and dramatist Romains. Romains' book was translated into English, entitled *Eyeless Vision*, in 1924. Romains investigated French women who claimed they could read without seeing, being blindfolded (Duplessis, 1975; Gardner, 1966).

One piece of evidence for tactile-colour sensitivity was replicated by Nash (1969): participants significantly distinguished black and red paper by touching without seeing ($p < .05$). Later, in response to Gardner's (1966) criticism of the lack of control of the peeking problem, a head box constructed of 3/8-inch thick plywood was employed (Nash, 1971). This box fitted over the participants' heads and rested on their shoulders and came completely under the chin to fit snugly around the neck. He found the same positive results as in his previous study of 1969 ($p < .001$).

A similar result was found among blind people. A 30 year old blind woman, who had been totally blind since the age of 18, was found to discriminate four colours on paper with a significant result ($p < .001$) (Moss, Gray, Hubacher, & Bush, 1972). Both blind and normally sighted people were found to be able to discriminate colours by touch on paper (Duplessis, 1978).

Overall findings

All studies reviewed suggest that fingers might be able to detect colours on paper. With respect to recognising printing, only one Western study, but all the Eastern studies found significant results.

One of the major differences between Western and Eastern studies is that Lee developed formal procedures targeted at children for developing finger-reading ability. According to this training paradigm, a visual experience accompanied with the correct answers was suggested to play the key role in helping participants successfully identify targets. This might indicate that reporting seeing a visual screen might be a good predictor of finger-reading ability. It is worthwhile investigating this claim. If finger-reading ability is real, one might expect its manifestations to be predictable. However, it should be noted that well-controlled conditions are of particular importance while conducting this investigation, as will be discussed later.

The other difference is that only children, and not adults were recruited as participants in the Eastern studies. As noted before, children seemed to perform better than adults did in Lee's finger-reading studies, revealing a reason for exploring ESP and children. Many parapsychological studies have focused on examining the relationship between adults and ESP, with little research examining children and ESP. In this regard, little is known about the topic of ESP in children. The cause of children performing better than adults did in Lee's studies is unknown. Indeed, over the years, researchers have noticed that children might be a potential group for demonstrating ESP ability (Bourgeois & Palmer, 2002; Rhine, 1965). Although it is not easy to conduct child parapsychological experiments, children might provide us with remarkable performances and phenomena (Alvarado, 2001). For example, some studies show a negative relation between ESP performance and aging (Bourgeois & Palmer, 2002; Shargal, 1987; Spinelli, 1977; Van Busschhach, 1959).

Problems and limits of the previous studies

Methodological problems

The very important issue of experimental controls developed and discussed in parapsychological studies provides a good checklist with which to examine finger-reading studies (Kennedy, 2004; Lamont & Wiseman, 1999; Milton, 1996; Morris, 1987, 1999, 2001; Steinkamp, Milton, & Morris, 1998; Wiseman & Morris, 1995).

Methodological problems in the Eastern studies: No satisfactory explanations of the phenomena were given, nor were the procedures described in sufficient detail in published reports done in Mainland China. Thus, the whole process cannot be evaluated. It is not clear whether the researchers ruled out fraudulent techniques such as those used in performance magic. For example, in 1981, children were caught peeking by scientists during finger-reading tests (Gardner, 1996).

Before examining Lee's finger-reading training paradigm, we should take a look at his training procedures. Lee's training procedures have never been mentioned in detail in any published journal. Most of the procedures depend on the first author's observations during the time when he worked with Si-Chen Lee, who helped to clarify some of the described procedures.

Summary of Lee's finger-reading training procedures: The stimuli consisted of 5cm × 8 cm rectangular pieces of paper. In the middle of each paper was a two-digit number in one of four different colours (black, green, blue and red) printed by an ink printer. There were two-digit numbers from 10 to 99. Confounding numbers, or "double chance numbers," such as 16 and 91, 19 and 61, 18 and 81, 66 and 99, 69 and 96, 68 and 89, 86 and 98, were excluded, so there were 76 numbers used in all. The trial samples were always prepared by a research assistant who did not participate in the finger-reading training process. They were folded twice and all put into a big envelope. Each sample was only used once in all procedures. In Training 2, the digit was replaced by a Chinese character. Sometimes, for example, in some special conditions, the stimuli were drawn on a 5cm × 10cm or 3cm × 10cm rectangular piece of white paper (Lee, 1998; Lee et al, 2000). Written or printed on the paper was a Chinese character or an English word or a symbol or mathematical formula.

A specialised black bag, used for handling photographic negatives, was employed as a barrier against sensory leakage. Two cuffs are snugly fitted around the participant's forearms and the bag has two layers, each with its own zipper. Hardly any light could enter the bag, as was empirically shown by a light detector. The participant could move and feel around freely within the bag. The purpose of the bag was to prevent the participants, experimenter and co-experimenters from seeing or peeking at the targets.

A three-stage, specialised training procedure was used in the experiments. Participants were first required to participate in 'warm-up training', where they watched a 30-minute videotape describing this "touch" phenomenon, such as how to identify the target. First of all, participants were required to sit and close their eyes and breathe deeply with a calm and peaceful mind for at least ten minutes. Then participants were required to practise image-making. The experimenter showed an object, such as a red apple, to the participants who were asked to look at the apple very carefully and remember every detail of it. Then they closed their eyes to visualise the apple exactly as they perceived it. Next, they visualise the apple changing its colour three or four different times i.e., through green, blue and black.

Participants then moved onto training procedure 1 which involved directly touching a two-digit number.The experimenter usually drew ten samples randomly from the big envelope and put them on the co-experimenter's chair. Then, the co-experimenter clenched one sample in his or her fist and put it the bag, and then closed the zippers. Participants must not see the target during this process. Next, participants put their hands into the two sleeves of the black bag and the sleeves were tied up. Participants were then required to open the folded samples and use their fingers to feel the targets. Participants were asked to focus on touch and to imagine that they can see the numbers while touching. There were no time restrictions and participants were free to use whatever scanning force and speed they chose. They removed their hands to write down the answer whenever they had told the co-experimenter what they saw, and the co-experimenter had recorded their response too. The co-experimenter then took out the training item from the black bag and showed the number to the participant. Thus, participants received feedback and the co-experimenter recorded if the participant's response was correct. Usually, children could try 20 items in one session within two hours.

Finally, participants who had a statistically significant performance level and subjectively report experiencing a subjective visual experience, usually a transparent screen in their mind, were invited to attend Training procedure 2, which involved directly touching a complex target (a Chinese character). This training procedure is the same as the training procedure for directly touching a target (a two digit number), but the stimulus was now a Chinese character. Sometimes, in special conditions, one experimenter and several co-experimenters carefully watched the participant in Training procedures 1 and 2.

Inadequate controls in Lee's procedures: The first issue in Lee's procedures is the problem of randomisation, as weak randomisation procedures are considered a serious problem (Bierman, Broughton, & Berger, 1998; Brugger & Taylor, 2003; Diaconis, 1978). A target should be selected randomly from target pools. The experimenter randomly drew several samples from the envelope (samples pool) and gave them to each co-experimenter. Plainly, this randomisation is inadequate.

Sensory leakage is also an issue in Lee's procedures, and this refers to participants obtaining information from sensory other than from extrasensory (Irwin, 2004). Usually, one co-experimenter worked with two participants, or sometimes three participants. The co-experimenter could not carefully observe each participant's responses and behaviour. The authors suggest that at least one experimenter and one co-experimenter or more work with each participant.

The experimenter put samples on the co-experimenter's chair and the participants cannot see the samples. Although the sample — a small piece of paper — was folded twice to prevent seeing or peeking, a remote possibility existed that the experimenter or co-experimenters might see the mark from the outside. The authors suggest that the samples should be put into an envelope before each trial.

The production of stimuli should be standardized in both procedures. Detailed information on how targets are prepared should be given. A tactile cue might be present due to different printing quality, especially in written samples. The procedures had not been examined by an expert in detecting fraud, so they may be open to cheating.

There is also an issue surrounding the participants and potential recording problems. The authors suggest that participants who have a history of nerve or brain injury, finger trauma, or learning disability (including dyslexia), diabetes (because of associated peripheral neuropathy) and callouses on their finger tips should be excluded. These factors might affect tactile learning results (Goldreich & Kanics, 2003; Vega-Bermudez & Johnson, 2004).

Although over two hundred children have taken part in Lee's finger-reading training, their psychological traits and demographical background have not been studied. Such information might provide useful explanations for the finger-reading effect. After discovering which variables best predict the finger-reading effect, we could be in a position to discuss which assumptions or theories are closely related to explaining the phenomena.

It is not clear if records of participants were double-checked by at least two different researchers/co-experimenters to avoid calculation error. Only individual scoring was analysed and not all the participants' trials were reported. All the trials for each participant should be clearly noted, as well as the method of analysis.

Methodological problems in the West: Likewise, Western finger-reading studies did not provide fully detailed information of randomisation procedures. They exhibit the same problems with participants and recording as described above. Sensory leakage is also a serious problem. For example, blindfolds have been found to provide only a rather weak control (Gardner, 1996). Wearing a pair of blindfolds was used in Novomeysky's and Romans's studies but this still provided only a weak safeguard against cheating, because it was possible for blindfolded people to see down through tiny openings made by muscular contortions or eye twitching. For this reason, it is not clear that Romains' investigation ruled out cheating.

Claims that the finger-reading studies lacked sufficiently tight controls to rule out trickery were often reported, with peeking being an especially common problem. For example, according to Gardner's report

(Gardner, 1996), one 13 year-old boy in a 1937 study claimed that he could name playing cards without seeing them. However, J. B. Rhine, the famous parapsychologist at Duke University, tested this boy with opaque goggles and found him to be cheating by peeking over the bridge of his nose. In 1962, a 22 year-old Russian epileptic patient claimed to be able read while blindfolded, but she, too, was caught cheating by scientists. Also, in another study (Zubin, 1965), a 15 year-old girl claiming to have this kind of ability was tested. She wore a blindfold taped to her face around its edge and was found to have tensed the muscles in the areas of her blindfold to cause a very tiny opening allowing peeking down the side of the nose.

Common problems and limits of the previous studies: Actually, methodological issues are a very serious problem in all finger-reading studies. In addition to the described problems, not one of reviewed studies provided fully detailed information about its safeguards. For example, measures to prevent cheating, such as a possible access to target pools, changing experimental records and replacing targets, should be implemented. Details of the materials and how targets are kept secure between being taken out of storage and being used in experiments must be noted. Clearly, bad methodological design has been a major problem in all finger-reading studies. Still worse, some of the participants have figured out how to cheat.

Regarding the printing quality, it was suggested we could accurately identify touch recognition in terms of about three levels of intensity (Geldard, 1960). We can detect a very small difference of particle sizes with thresholds between .0024 and .0033 mm and the difference of ridge height thresholds was between .00095 and .002 mm (Miyaoka, Mano, & Ohka, 1990). Different printed colours might cause different levels of touch intensity, providing a tactile cue to detect different colours, especially when the participants only had to discriminate two colours on the same trial in Novomeysky's study. The details of how the samples were obtained were not fully noted in all previous finger-reading studies. In this case, the possibility of tactile cues cannot be excluded.

Finally, there is an issue surrounding replication. If the finger-reading effect cannot be replicated reliably, it will lose credibility. Many researchers (Alcock, 2003; Burns, 2003; Jeffers, 2003; Milton & Wiseman, 1999, 2001) have pointed out that no sufficient evidence has proved the existence of ESP. The results of ESP performance have been found elusive, weak, unreliable and lacking in quantity (Kennedy, 2001). This leads to other problems, such as unpredictability, lack of progress and failure to propose coherent explanatory theories (Alcock, 2003). Likewise, the finger-reading effect is now facing the problem of replication. No-one has replicated Lee's finding using his training paradigm.

The reviewed studies indicate that fingers might be able to recognise colours on paper, but are vulnerable to poor methodology as above. The methodological quality of a study is an important criterion for its inclusion in a meta-analysis (Rosenthal, 1995). For this reason, the authors suggest that all of these studies cannot be selected in any meta-analysis.

In summary, replication of the finger-reading effect with respect to recognising colours or print is wanting.

Incomplete potential mechanisms and explanations

Attempts to explain the finger-reading effect have been made. One of the very important questions was "Can our skin see or perceive radiation?" For instance, perceiving light or radiation has been suggested as a possible normal explanation of the finger-reading effect. In one experiment (Barrett & Rice-Evans, 1964), the participants were given a dim and low-level visible light condition (.00012 lumens/cm^2). It was of 3.5 times the intensity of the black condition. No participant showed a significantly improved performance.

To the best of our knowledge, retinal photoreceptors are only found in the eye's rod and cone cells, with an exception that photoreceptors, which contain light-absorbing photopigment, are found not restricted to just rod and cone cells in the salmon's eyes (Soni, Philp & Foster, 1998). It is suggested that, evolutionarily, pigment cells in the skin may be precursors of the photoreceptor cells in the eyes (Arnheiter, 1998). However, the human skin only unconsciously responds to light, especially the ultraviolet-B (UVB) light (290–320nm) and ultraviolet-A (UVA) light (320–400 nm) wavelengths, resulting in the production of vitamin D and thus affecting skin pigmentation. The level of skin pigmentation works to prevent UVB radiation damage (Slominski, Tobin, Shibahara, & Wortsman, 2004). Light-absorbing photopigment, reactive to 400-700nm, has not been found in human skin. The existing evidence indicates that human skin cannot "see".

Regarding detecting radiation, everything has its own radiation. For example, in a paper with printed characters, the printed targets and the paper involve different materials. Thus, it is logical to infer that they have different radiation levels, which might, perhaps, lead to different levels of radiation feedback. Fingers might be able to detect the differences in radiation reflected by colours. To test this hypothesis, several attempts have been made. A higher level (60 watt lamp) testing box comprising two compartments separated by a sheet of frosted glass was used (French, 1965). Then a stack of 72 cards was put in the box. Black and white were used for the cards. The participant put one hand inside the box to go through the pack of cards and then guessed its colour under two conditions: one with the light on and the other one with light off. No positive results were found. In another study (Passini & Rainville, 1992), blind and blindfolded participants were tested to see if they could discriminate colours on boxes in normal light condition, but the result did not support this idea.

Although many workers (Jacobson, Frost & King, 1966; Markous, 1966; Nash, 1969, 1971; Novomeysky, 1965; Youtz, 1966) support the hypothesis of that human fingers might be able to detect radiation, all studies exhibit methodological problems. In Nash's and Novomeysky's studies, their methodological problems are as above. It was not clear if the experimenter was ignorant of the targets used in Jacobson's study. In Markous's study, only three of six participants used an aluminium box to prevent peeking. Youtz has not yet published a full account of his work, though he did use a blindfold as a safeguard. Again, they all did not provide fully detailed information of the experimental process and safeguards.

This hypothesis has not been proved. Presumably, we need to investigate whether this finger-reading effect is measurable, then it could be appropriate to explore the basic properties of it in order to develop assumptions or theories to explain it.

Future research

The finger-reading effect has never been proved. To solve this problem, the answer is simply to run finger-reading experiment under well-controlled conditions. The authors suggest adopting the paradigm originally developed by Si-Chen Lee to further explore this finger-reading effect, which now has been modified and is being tested by the authors.

The finger-reading procedures are developed from Chinese culture. One might ask whether it can be applied in Western culture? Needless to say, no studies of this issue have been undertaken. To answer this question, the authors would initially make the assumption that ESP might be an ability common to all humans. It is a good strategy that researchers observe what is going on when finger-reading studies are conducted in Western society.

If the finger-reading effect is true, the assumptions would be as follows:

1. Our fingers might be able to detect printing with a very low elevation, even a nearly zero elevation, probably through unknown functions in the fingers. This would be a new and astonishing discovery about sensory abilities.

2. The finger-reading effect might involve some new means of perception beyond those presently understood.

3. In fact, no one has produced any plausible or satisfactory explanation for the finger-reading effect or any new means of communication. The most difficult aspect is whether to attribute it to the first assumption or the second assumption. This effect might involve *both* exceptional tactile ability and some new means of communication.

With regard to the assumption one, the limit of relief recognition needs to be assessed first. For example, the finger-reading task used in Lee's studies was ink-printed text, which is in a range of 1–20 microns (.001–.02 mm in elevation). Usually, the paper absorbs most of the ink. One might expect that this ink-printed text is near zero in elevation. However, the true elevation of the text still needs to be precisely determined. To our knowledge, the relief recognition task and Braille reading are the most similar to this tactile touching task in finger-reading studies. In a previous study, an elevation of .5 mm has been shown to lead to correct recognition of letters in normal sighted adult people (Vega-Bermudez, Johnson, & Hsiao 1991). However, there are no studies of recognition using printed text and rarely have studies been conducted on the limits of relief recognition. In other words, the elevation between .49 mm and zero has not been explored so far. But there is some evidence that people may have abilities within this range. Braille characters are a good measure for spatial acuity, because they have been devised to assess the ability to resolve fine spatial form (Craig & Johnson, 2000). It was proposed that Braille pattern recognition is based on shapes outlined by the dots (Loomis, 1981), which can be considered as a relief recognition. One previous study has shown that normal sighted people can distinguish Braille patterns of .3 mm in elevation, while people who are blind from an early age can identify Braille patterns of .2 mm in elevation (Grant, Thiagarajah & Sathian, 2000). Assuming that Braille pattern recognition is similar to a relief recognition, the authors hypothesise that a relief recognition of .3 mm may be discovered. The authors are currently testing these hypotheses. It is vital to explore the limits of relief recognition since the results of these experiments will serve three important functions. Firstly, the limits of the tactile recognition of alphanumeric figures can be determined, as previously research has concentrated only on the recognition of Braille figures. Secondly, the value below threshold of tactile relief recognition will be applied to produce the touching samples used in later experiments, with the aim of ruling out the possibility of tactile cues. Finally, it can be regarded as a control experiment comparing the later finger-reading training experiment, since the former experiment will not involve any training procedures.

Any new sensory function of fingers or a new means of communication will need to be reconsidered and further explored, if fingers identifying printings with an elevation much below threshold is found in later research. If it is real, further investigation into underlying mechanisms can be done later, as studying it can tell us about exploring exceptional performance and how to enhance this. Theories might then be developed to account for the finger-reading effect.

In summary, the authors suggest that the limits of tactile relief recognition needs be determined. The finger-reading ability needs to be further explored under well-controlled conditions, especially in children.

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Appendix 2: "Towards a replication of the finger-reading effect" as published in the Journal of Parapsychology 2005

TOWARD A REPLICATION OF THE "FINGER-READING" EFFECT

By Yung-Jong Shiah

ABSTRACT: The "finger-reading" effect refers to successful identification by touch of apparently flat target numbers, colours, words, or symbols on paper in conditions where the participant is unable to see, or feel, or have any normal sensory cues to assist tactile identification. Studies of this have been running for over a decade in Taiwan. Nearly a quarter of children, after several finger-reading "training sessions," have appeared to be able to determine the identity of targets by means of directly touching a 2-digit number or a complex character varying in 4 different colours printed by an ink printer on paper. Training procedures developed by Si-Chen Lee appeared to yield exceptional tactile recognition or extrasensory perception via the fingertips of children. However, these results may be unreliable due to a lack of rigorous controls to rule out possible fraud. It is thus not yet safe to assume that parapsychological abilities were in fact successfully measured. In this paper, pilot trials are considered that would develop empirically and assess controls on the finger-reading training processes. Modifications to training procedures are proposed. If the finger-reading effect can be replicated under robust and credible conditions, then perhaps more research resources could be attracted to investigating the possibility of exceptional and parapsychological finger-reading abilities in children.

The present paper builds on work described in previous papers on the finger-reading effect (Lee, 1998, 1999, 2002, 2003; Lee & Chang, 2001; Lee, Chen, & Tang, 2000; Lee, Tang, & Kuo, 2004; Tang, Lee, & Hsu, 2000). The detailed finger-reading literature review can be seen in the author's paper (Shiah & Tam, 2005). This paper will focus on the finger-reading training paradigm developed by Si-Chen Lee. There, the average success rate in recognition (by a $p < 0.05$ criterion) by means of directly touching a two-digit number or a complex character varying in four different colours printed by an ink printer on paper was 24% (41 out of 173 participants) (Shiah & Tam, 2005).

Children for whom the techniques seemed to be successful reported that distinctive visual images had accompanied their successful trials. These visual images appeared as if seen in the real world. The children subjectively reported seeing answers on a "transparent" screen, sometimes an "opaque" screen (Lee, 1998, 1999; Lee, Chen, & Tang, 2000; Shiah & Tam, 2005; Tang, Lee, & Hsu, 2000). Children appeared to easily recognise complex characters or other complex symbols after seeing an opaque or distinct screen masking their normal vision. Having this visualising experience of an opaque screen in the mind correlated highly with correct recognition of targets. One approach would involve using more complex characters that would in turn produce more complex visual imagery in the children's minds.

The possible existence of finger-reading ability gives rise to three important issues. First, the results of extrasensory perception (ESP) have generally been found elusive, weak, unreliable, and lacking in quality (Kennedy, 2001). ESP is a general term used for all paranormal abilities that cannot apparently be explained in "rational" terms (Irwin, 2004). Many researchers (Alcock, 2003; Burns, 2003; Jeffers, 2003; Milton & Wiseman, 1999, 2001) have concluded that there has not been sufficient evidence to support the existence of ESP. However, according to Lee's findings, nearly a quarter of unselected participants were capable of showing finger-reading ability after training. This is a decisive effect, suggesting that a strong and reliable finger-reading ability might exist.

Secondly, it has been claimed that ESP ability could be trained by repeated practice with positive results (Braud & Wood, 1977; Honorton, 1970; McCallam & Honorton, 1973; Ryzl, 1962, 1966; Ryzl & Pratt, 1962; Targ & Tart, 1985; Tart, 1966, 1975, 1977, 1986; Tart, Palmer, & Redington, 1979). On the contrary, this assumption has not been supported in other studies (Beloff, 1967; Delanoy, 1986; Fourie, 1977; Gissurarson, 1990; Jackson, Franzoi, & Schmeidler, 1977; Morris, Robblee, Neville, & Bailey, 1977; Stanford, 1977; Utts, 1995; Vitulli, 1983). If ESP phenomena are real, we still do not have a reliable method for eliciting them, so it might be worthwhile investigating how this training procedure might work.

The third issue is that the quality of the subjective visual imagery reported by participants plays a key role in successfully identifying targets. This might indicate that vivid imagery is a good predictor of finger-reading ability. As described above, there are two reported levels of visual imagery. One is that seeing a transparent screen indicates some successful recognition of targets. Another is that seeing an opaque screen indicates a still higher success rate at recognizing targets. If finger reading is real, one would expect its manifestations to be predictable.

However, we can formulate clear but basic questions: Is the finger-reading effect real/replicable? Were all the successful studies merely replicating errors and vulnerable to fraud? To date, the results of the finger-reading effect are subject to criticism (Du, 2005). For instance, the finger-reading effect may have involved merely normal tactile ability or may have resulted from fraud due to a lack of stringent safeguards (Shiah & Tam, 2005). Thus, more stringent safeguards need to be considered for these procedures.

Before additional finger-reading experiments are conducted, this paper aims to make the finger-reading training procedures more stringent. The development of the ganzfeld technique provides a good model for finger-reading training procedures. The ganzfeld technique involves participants experiencing target-related imagery under sensory deprivation conditions (Irwin, 2004). The ganzfeld technique is regarded as providing a good research tool to produce replicable evidence of psi ability (Utts, 1991). This is because much effort has been made to modify the procedure and safeguards to meet strict standards (Goulding, Westerlund, Parker, & Wackermann, 2004). Thanks to the ganzfeld technique developments of the 1970s (Braud, Wood, & Braud, 1975; Honorton & Harper, 1974), the procedure is now highly shielded against sensory leakage (Morris, Summers, & Yim, 2003). The technique was tested and modified in more than 100 studies over the last three decades (Palmer, 2003; Parker, 2003). ("Sensory leakage" occurs when participants obtain information sensorily rather than extrasensorily [Irwin, 2004].)

Following the example of the ganzfeld technique, the author proposes three stages to develop a well-controlled paradigm of finger-reading training. The first stage is to examine the original finger-reading training procedures in order to obtain sufficient information to design "temporary" training procedures. In the second stage, this temporary training paradigm will be empirically tested. Finally, a well-modified finger-reading training paradigm will be proposed for future research. An experienced parapsychologist, the late Professor Robert L. Morris, was involved in suggesting modifications to this training paradigm.

Methodological Problems With Finger-Reading Training Procedures

The major problems with ESP experimental designs are: interpretations as coincidence, poor observation, deception, and sensory leakage (Hansen, 1990; Milton, 1996; Morris, 1999; Steinkamp, Milton, & Morris, 1998). In order to eliminate those problems, the original finger-reading procedures were initially examined in a recent study (Shiah & Tam, 2005). The procedures and issues associated with inadequate controls are outlined briefly below. In addition, pilot trials will be conducted to develop procedures empirically and examine controls on the finger-reading procedures. Modified procedures are proposed.

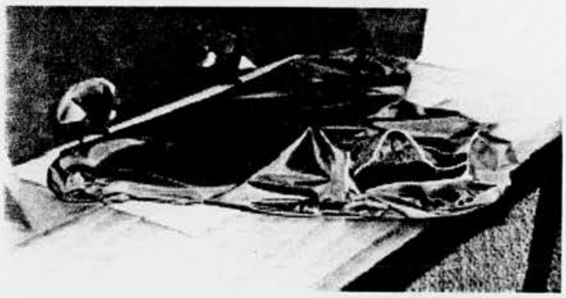
Material

The stimuli consisted of 5 × 8 cm rectangular pieces of paper. In the middle of each piece of paper was a two-digit number from 11 to 99 in one of four different colours (black, green, blue, and red) printed by an ink printer. Confounding numbers, or "double chance numbers," such as 16 and 91, 19 and 61, 18 and 81, 66 and 99, 69 and 96, 68 and 89, 86 and 98, were excluded, so there were 75 numbers used in all. The trial samples were always prepared by a research assistant who did not participate in the finger-reading training process. They were folded twice and all put into a big envelope. Each sample was used only once in all procedures. In Training

2, the digits were replaced by a Chinese character. Sometimes, for example, in some special conditions, the stimuli were drawn on a 5 × 10 cm or 3 × 10 cm rectangular piece of white paper (Lee, 1998; Lee, Chen, & Tang, 2000). Written or printed on the paper was a Chinese character or an English word or a symbol or a mathematical formula.

Barrier

The barrier (see Figure 1) is a black bag normally used for handling or changing photographic negatives (double-lined changing bag, 45 × 60 cm, Hakuba Photo Industry Co., Ltd.). Two cuffs are snugly fitted around the participant's forearms and the bag has two layers, each with its own zipper. Hardly any light could enter the bag, as was empirically shown by a light detector. The participant's hands could be moved freely within the bag. The purpose of the bag was to prevent the participants, experimenters, and coexperimenters from seeing the targets.



1a. The bag has two layers, each with its own zipper.

1b. The participant's two hands are fitted into the bag.

Figure 1. The experimental bag

Warm-Up Training Before Finger-Reading Training

Participants were first required to watch a 30-min videotape describing this "touch reading" phenomenon, including how to identify the target. First, participants were required to sit, close their eyes, and breathe deeply with a calm and peaceful mind for at least 10 min. Then participants were required to practise image-making. The experimenter showed an object, such as a red apple, to the participants, who were asked to look at the apple very carefully and remember every detail of it. Then they closed their eyes to visualise the apple exactly as they perceived it. Next, they visualised the apple changing its colour three or four different times, e.g., to green, then to blue, and finally to black.

Training Procedure 1: Directly Touching a Two-Digit Number

The experimenter usually drew 10 samples randomly from the big envelope and put them on the coexperimenter's chair. Then the co-experimenter clenched one sample in his or her fist, put it into the bag, and closed the zippers. Participants must not see the target during this process. Next, participants put their hands into the two sleeves of the black bag and the sleeves were tied up. Participants were then required to open the folded samples and use their fingers to feel the targets. Participants were asked to focus on touch and to imagine that they could see the numbers while touching them. There were no time restrictions and participants were free to use whatever scanning pressure and speed they chose. They removed their hands to write down the answer after they had told the coexperimenter what they saw and the coexperimenter had recorded their response. The coexperimenter then took out the training item from the black bag and showed the target number to the participant. Thus, the participants received feedback and the coexperimenter recorded whether each participant's response was correct. Usually, children would attempt 20 items in one session, lasting 2 hr.

Training Procedure 2: Directly Touching a Complex Target (a Chinese Character)

Participants who had a statistically significant performance level were invited to attend this further session. Most of these reported experiencing a subjective visual experience when recognising the targets, and many of them described seeing a transparent or opaque screen in their mind. This training procedure was the same as the training procedure above for directly touching a target (involving two-digit numbers), but the stimulus was now a Chinese character. The purpose of the training was to help children to have the superior imagery function that tends to be associated with experiencing an opaque visual screen. It was found that an opaque screen occasionally occurred in this training session. This might account for the better ability to correctly identify targets. Sometimes, in special conditions, one experimenter and several coexperimenters carefully watched the participant in Training Procedures 1 and 2.

Methodological Problems

There are three obvious methodological problems with these procedures as pointed out in the past (Shiah & Tam, 2005). The first is randomisation. A target may not have been randomly selected from the target pools. The second problem regards sensory leakage. For example, the detailed information on how targets are obtained was not described. The production of stimuli was not standardized in all procedures. Third, fully detailed information of safeguards was not provided. Usually, one coexperimenter worked with two or sometimes three participants. The coexperimenter could not therefore reliably observe each participant's responses and behaviour.

Pilot Trials

A pilot study ought to be conducted before a formal experiment, not only to maximize the possibility for participants to show their ESP ability but also to assess the efficacy of the controls that will be used in the formal experiment (Wiseman & Morris, 1995). In this regard, the author has carried out pilot trials of finger reading in Taiwan. One of the main purposes was to check the entire training procedure in order to develop effective barriers against possible fraud in later experiments. The other purpose was to examine whether Lee's finger-reading effect had any potential for use in further work. Twenty-two participants aged from 7 to 11 were recruited. They were trained to feel directly a two-digit number or a Chinese character on paper printed by an ink printer. In response to the inadequate controls described above, modifications to overcome these shortcomings in the author's pilot trials were made.

Although the overall results of the author's pilot trials indicate a significant result, it should be noted that the finger-reading procedure was vulnerable to cheating. For example, peeking behaviours might occur when the participant touched the target in the black bag. Participants might have seen the samples through an opening created by pulling at the two tight cuffs of the bag. Moreover, during the process of touching a target, the participants were allowed to remove their hands from the bag to write down their answer; then they could put their hands back in the bag. This would increase the possibility of peeking behaviours. For these two reasons, the author will not report the results of these pilot trials in this paper.

Toward a Replication of "Finger-Reading": Modifying the Training Procedures

Before the modified finger-reading training procedures are proposed, two problems need to be solved. This first is the peeking problem. To solve this problem, the author suggests adding eight new strategies. First, the author has designed an effective barrier, which is an 80 × 80 cm black screen with two cuffs snugly tied around the forearms. The barrier has two holes for the forearms to be inserted through before they then enter the black bag. The two holes of the screen are 8 cm in diameter and are 1.5 cm from the bottom. The distance between them is 15 cm. This screen can be set up on the table between the participant and the bag (see Figure 2). Second, the author suggests that at least one experimenter and one coexperimenter should closely monitor the participant, with one positioned on each side of the barrier. Third, experimenters and coexperimenters should make sure that the hands are properly inserted into the cuffs and that the barrier and bag are snugly tied/fitted around the forearms. Peeking can only take place if any gaps in the barrier-cuff and the bag-cuff are lined up exactly, as the participant could then conceivably peer through any small gap, although this would be impossible to achieve without the observers immediately noticing the participant contorting his or her body in order to see through the gap. Fourth, a part of the participant's arms should be exposed (see Figure 2b). Thus, any attempts at lining up gaps in the cuffs of the bag and barrier will be easily observed. These modifications should make peeking impossible, but in addition, fifthly, the author suggests using a video camera to record the whole process. Thus, the possibility of unnoticed peeking, perhaps as a result of the experimenters and the coexperimenters not observing closely enough, could be ruled out. The ideal view for recording the process must include the cuffs of the bag and the screen (see Figure 2b), as these are the only possible areas where gaps could be lined up. The recorded data should be viewed by a different researcher to check whether any peeking took place.

Sixth, the trial should be considered invalid when participants pull at the tight cuffs of the bag or the screen to make openings. Seventh, participants should not move their arms unnecessarily or pull at the bag or cuffs during touching, to minimise possible peeking in terms of causing any openings of the cuffs of the bag and the screen. Finally, the sample should be placed in a sealed opaque envelope to ensure that the experimenter/coexperimenter and participants cannot see it and that the envelope is not opened until it has been inserted into the double-zipped bag. The sealed envelopes can be put into an opaque plastic bag. The purpose of a sealed opaque plastic bag is to avoid the envelope's being rendered transparent by the application of water, alcohol, or oil. The opaque plastic bag can be put into a big envelope, which should be signed by the research assistant and be sealed with tape at both ends so that any tampering would be detected. The envelope or plastic bag should be tested under sunlight or strong light to prove that the targets cannot be seen. Under this condition, it is impossible to see any targets in the big envelope containing envelopes. Participants should not have a chance to see envelopes containing targets before or during the experiment. Under these arrangements, experimenters and coexperimenters too should not be able to see any targets.

The other question to be addressed is whether tactile cues might account for the finger-reading effect. The tactile task used in the finger-reading studies and the author's pilot trials involved ink-printed text, which is in a range of 1-20 microns (0.001-0.02 mm) in elevation. It is hypothesised that the paper absorbs most of the ink, implying a near zero elevation. To verify this hypothesis, the surface topology of the printing in terms of four different colours was investigated by means of the novel 3D surface profiler instrument Dektak 3, (Veeco Instruments, Inc.). The remarkable features of this instrument are its wide range of scanning area (∼50 mm) and high vertical resolution (∼0.01 nm). The horizontal and vertical axes of the printing were scanned to measure distance and vertical height, respectively. The printing in terms of a two-digit number or a three-letter English word was on a 5 × 8 cm rectangular piece of paper (A4 white 75 g/m^2; H. E. Copier). Each digit or English letter size was 24 points in Times New Roman printed by a Hewlett Packard Officejet G85 colour printer. The result indicates that ink elevation and paper roughness cannot be distinguished, indicating a zero elevation.

The Modified Finger-Reading Training Procedures

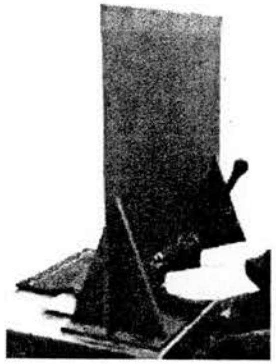
In view of the peeking problem and inadequate controls described above, many safeguards will be used in the finger-reading processes in order to prevent possible fraud. The detailed materials and precise procedures for researchers to explore the finger-reading effect will be provided as an example.

Participants

According to Lee's findings, participants aged 7 to 13 are promising recruits. Participants who have a history of nerve or brain injury, finger trauma, or learning disability (including dyslexia), diabetes (because of associated peripheral neuropathy), and calluses on their finger pads should be excluded. These factors might affect tactile and learning results (Goldreich & Kanics, 2003; Vega-Bermudez & Johnson, 2004).

Prespecifications

Experimenters have the right to declare a trial invalid if any of the following occurs:



2a. The screen with two tight cuffs 2b. The screen set between the participant and the bag

Figure 2. The experimental screen

1. A participant takes the stimulus out of the black bag
2. A trial is interrupted
3. The tight cuffs of the screen or bag are pulled at by a participant to cause an opening
4. A participant is unable to successfully open the envelope and extract the target under these "blind" conditions

Hypotheses and analyses should be specified in advance.

Barriers

The author suggests three kinds of barriers. As described before, the first is the screen, the second is the black bag, and the last is the video recorder.

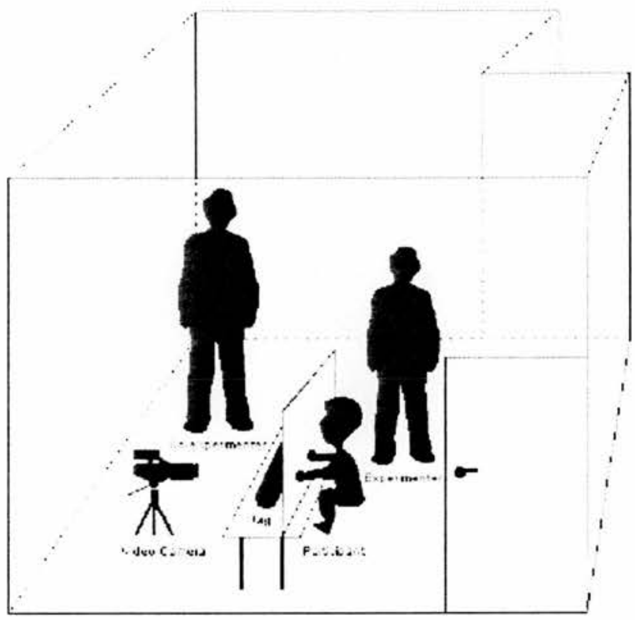


Figure 3. Participant, experimenter, coexperimenter, and relevant equipment

Experimental Room

To guard against peeking, the room should be isolated and without windows, mirrors, or holes. One experimenter, one coexperimenter, and one participant should be in the room when the experiments are being conducted. The coexperimenter should give the participants the stimuli and record their responses with a video recorder as well as observing them. The experimenter should only record and observe participants' responses and behaviours. The author suggests that one experimenter and one coexperimenter stand on each side of the screen (see Figure 3). The participant's behaviour should be clearly monitored. Thus, the general guideline for the positions of an experimenter, a coexperimenter, and a video camera is that the frame of observation must include a clear view of the participant's hands, the cuffs, and the bag. The best view for a video camera can be seen above in Figure 2b. All participants' responses should be videoed in case the need for checking any details arises.

The Procedure of Touching the Two-Digit Number Directly

Touching stimuli. All experimental samples should be prepared in advance by a research assistant who will otherwise not be involved in the experiment. The coexperimenter who handles the target envelopes should have no relationship or contact with the assistant who prepared the targets.

The target stimuli should be produced in a strictly standard way: A two-digit number from 11 to 97 varying in four colours (e.g., red, green, blue, and black) should be printed in the middle of the paper. Numbers and their colours should be randomly generated by a computer generator designed by Paul Stevens, a research fellow of the Koestler Parapsychology Unit at Edinburgh University. The stimuli should be generated using a pseudorandom sort routine (based on the Microsoft Visual Basic RND function, seeded by the computer timer at the start of the program). The 75 numbers used should be the same as Lee's. A number with a colour should be randomly selected as a replacement; thus, the same targets could possibly be repeated. This is the most unpredictable randomisation, having no patterns that participants could possibly predict. Each trial will be independent from every other. For example, in each trial, each target with a particular colour always has a 1 in 300 chance—mean chance expectation (MCE)—to be randomly selected by the computer programme. Subsequent trials will be chosen from the original pool, meaning these also have a probability of 1 in 300.

Based on previous experience, a participant could usually try 20 samples in a section within 2 hr. Thus, the computer generator should be set to generate a certain number of sets of 20 targets at once. However, note that researchers can decide the number in each set as needed. All targets prepared for all participants will be generated in a single run by the computer generator. This means that the planned targets for all participants will be generated after running the computer generator in a single run.

The sample can be made up of 5 × 8 cm rectangular pieces of paper (A4 white 75 g/m^2; H. E. Copier). Each digit's size can be about 0.6 × 0.5 cm (Times New Roman, 24 points) printed by a Hewlett Packard Officejet G85 colour printer, which was confirmed to produce a zero elevation. It has been suggested that there is a close parallel spatial relationship between tactile character recognition and visual recognition (in millimetres) (Loomis, 1990). The size of the character is not crucial for a successful tactile identification but the bandwidth, namely visual legibility, is important. The digit size used here was very easy for visual identification; accordingly, it was presumed to be relatively good for tactile identification.

Each sample should have a fold with a 1.5 cm length on the top left corner (see Figure 4) as a cue for participants to touch the target exactly. The person who prepares the samples should use a meter scale to make sure of the right length. Sheets should be folded before the numbers with colours are printed on them to avoid possible frauds. Specifically, note that the fold should be made before the target is randomly selected by the computer generator. If not, for example, the fold might be made slightly bigger if the number is higher, giving participants a cue to make a comparable judgment. Likewise, one corner of the paper could be cut to indicate which way is up. Participants were informed by other means to help the orientation in pilot trials before. They were told that the printing on the paper faces the front of the envelope, that the bag and target are not upside down, and that the front of the envelope faces the front (zipper side) of the bag. However, some of the participants were confused about the orientation of the target in the "blind" condition. This might lead to a psychological effect on participants' performance and is the reason why a fold is suggested to avoid such confusion.

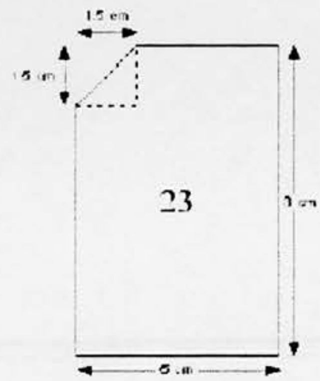


Figure 4. The target sample and its fold

Each stimulus is put into a sealed opaque envelope of 15.2 × 8.9 cm size (Niceday envelopes, manila plain 70 gsm, gummed, product code 182543, Guilbert Company). The 20 envelopes in a pile are put into an opaque plastic bag. Each envelope is discreetly numbered to aid double-checking of results. The opaque plastic bag can be put into a 22.9 × 16.2 cm opaque envelope (Niceday envelopes, manila plain 90 gsm, gummed, product code 183422, Guilbert Company). This big envelope should be signed by the research assistant and be sealed with tape at both ends so that any tampering would be detected by the coexperimenter who cuts open the envelope during the experiment. The big envelope should not be opened until the experiment. These two types of envelopes and plastic bags were tested under sunlight to prove that targets cannot be seen. It was found to be impossible to see any targets in the big envelope within the plastic bag containing the 20 envelopes. Each set of envelopes should be numbered faintly 1-20 (for experimenters' recording procedure only) by pencil on the outside, which is not detectable by touching. Each small envelope can be sealed with its gum, yielding no different feeling between envelopes. Each piece of paper needs to be placed exactly in the middle of each small envelope. The short side of the paper needs to contact the bottom of the envelope. The printing on the paper needs to face the front of the envelope, ensuring that the printing is not upside down (see Figure 5).

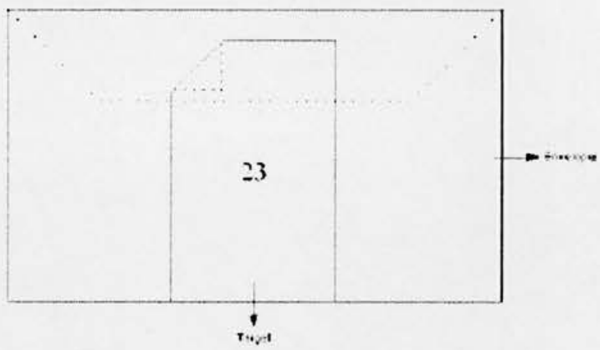


Figure 5. The target sample and its envelope

The stimuli, small envelopes, plastic bags, and big envelopes should be used only once. Thus, participants cannot receive any target feedback marked on those materials by previous participants. The stimuli should be stored in a different room, to which neither participants nor the coexperimenter has access. Participants should not see any targets or their containers until receiving feedback. The research assistant who prepares the samples should save detailed information about the list of the stimuli in a secure computer and a copy on a disk in a sealed opaque envelope. Only the research assistant should have access to the computer and the sealed envelope containing the disk. This sealed envelope should be opened only after the experiment has been conducted. A double check of the stimuli after the experiment can be done to find possible recording errors or cheating by replacing samples.

Finger-reading procedure. Before the experiment, participants should be asked to show that their hands are empty and especially not concealing any trial samples used in the experiment. The coexperimenter should make sure that the black bag is empty between trials. The purpose of these checks is to prevent conjuring tricks being used to conceal trial samples. Additionally, the participants should not be allowed to carry any mobile phones or radio equipment to guard against communication with any possible accomplice.

Warm-up training before the finger-reading training. The training period should not exceed 2 hr a day due to children's limited attention. There can be a 15-min break each day, during which participants can be rewarded with drinks or snacks.

The process begins with warm-up practice. First of all, the experimenter turns the light off. Participants should be required to sit, close their eyes, and breathe deeply with a calm and peaceful mind for at least 3 min, after which the light should be put back on. Then participants should be required to practise "image making." The experimenter should show a simple object such as a red apple to the participants, who should be asked to look at the apple very carefully and remember every detail of it. Then they should close their eyes to visualise the apple exactly as they perceive it. In Lee's and the author's pilot trials, all of the children seemed to be able to perform this task. Once they can do this, they should try to visualise the apple changing its colour three or four times, i.e., through green, blue, and black. Participants should also see a demonstration describing the "touch reading" phenomenon, including how to identify the target.

Procedure for Touching a Two-Digit Number

Participants can be given three to five practice tries. The experimenter should give the coexperimenter one big envelope containing a plastic bag inside which are 20 small envelopes. The coexperimenter should open the sealed big envelope, take one small envelope from the plastic bag, put it into the black bag, and then close the zippers. The rest of the small envelopes should be kept in the plastic bag until required. Thus, participants should not see any envelopes during this process. Participants tended to avoid calling previous targets in the guess sequence in ESP tasks (Ertel, 2005), although this guessing strategy cannot raise the probability of hit rate. Participants should be clearly informed of the meaning of randomisation.

Next, participants should put their hands into the two tight cuffs of the screen and the black bag. They should be required to open the sealed envelope to take out a target sample to scan using their fingers. According to the participants' experience in pilot trials, it was found to be easy and quick to open the envelope to remove the target paper without tearing the paper or adding additional folds. Participants should be taught to tear the very end of right or left side of the envelope to remove the target paper because the target paper will be in the middle of the envelope.

During the finger-reading training procedure, the participants should be required to focus on touch and to imagine that they can see the numbers while touching the target. They should be told that there is a fold in the top left corner as a cue for them to touch the target exactly. Participants should be told not to add any additional folds or any marks on the target paper to keep targets intact so they can be checked later if necessary by another independent researcher to see if any obvious patterns were made by the person who prepared the targets.

There are no time restrictions, and participants are free to use whatever scanning pressure and speed they choose. They should be asked to inform the coexperimenter about whatever they see and feel. They cannot take their hands out of the black bag during the touching procedure. Participants should be told that pulling at the bags or cuffs is not allowed, and to avoid any unnecessary movement of their arms. They can take their hands out of the black bag only after they tell the coexperimenter their final response. In the meantime, the coexperimenter and the experimenter should record the participants' responses and response times.

After the participant finishes the trial, the coexperimenter takes out the item from the black bag and shows the number with its colour to the participant. Participants therefore get feedback and the coexperimenter is able to record whether the participant's response was correct. The reason for giving feedback is so that participants are able to learn whether their judgments are accurate. It is hoped that this will help to induce and improve any finger-reading ability in terms of permitting a target-related image to come to mind. According to previous experience, children could try around 20 items within 2 hr. Each participant should try at least 80 samples in this experiment over 4 different days, or more if time allows.

If participants want to have a break during the experiment, the coexperimenter should seal the big envelope containing the plastic bag holding the rest of the samples and put it into another isolated room. The experimenter should lock the room so that no one can access the room and the samples.

It should be noted that the sequence of targets presented to participants should not be changed. If a set of 20 targets cannot be completed by a participant, the next participant can use the rest of them. Statistically, this action cannot affect hit rates since the targets are selected randomly. The big envelope containing the plastic bag holding the unfinished samples should be signed by the coexperimenter and sealed with tape at its opened end. The experimenter should store the big envelope in another locked room.

If participants succeed in three consecutive correct recognitions of numbers with their colours, in addition to giving their verbal reports, they should be asked to describe and draw how they visualised their correct answers. This might provide possible answers as to how children decide their responses in their minds and about the details of mental imagery. Three hits reach a significance ($p < .05$, binomial, one-tailed, MCE = 1/300) when total trials are 245 for each participant. As a result, 3 hits could be a good score when total trials of a participant do not exceed 245.

It has been suggested that the light might reduce the chances of recognising colours (Tang, Lee, & Hsu, 2000). Consequently, the author suggests using light while conducting the finger-reading studies, but the issue of whether light is necessary for recognising colours should be further explored in later studies.

Procedure for Touching an English Word Directly

Earlier it was noted that seeing a "screen" played an important and common role in successfully recognising targets while touching stimuli; the screen was reported by the children to last for several seconds. There are two reported forms of screen: transparent and opaque. The transparent screen was frequently activated when the children directly touched a two-digit number, and the opaque screen was more often activated as children directly touched a complex target. The author suggests that in future studies a complex target should be used, such as an English word.

Participants who report having seen a transparent screen with a positive result in the first experiment should be invited to take part in this experiment. The safeguard considerations, touching stimuli, barriers, and procedures should be the same as described for touching a two-digit number directly. However, the warm-up procedure can be omitted in this study.

The target stimuli should be replaced by a three-letter meaningful English word in capitals. The data pool can include 1,002 different three-letter English words derived from MRC Psycholinguistic Database (http://www.psy.uwa.edu.au/mrcdatabase/uwa_mrc.htm). A computer programme, again designed by Paul Stevens, can randomly choose the target words for producing samples using a pseudorandom sort routine.

Similarly, if participants succeed in three consecutive correct recognitions of numbers with their colours, they should be asked to describe and draw how to get answers afterward. Three hits reach significance ($p < .05$ binomial, one-tailed, MCE = 1/4008) when total trials are 3,270 for each participant. As a result, three hits could be a good success rate when the total trials of a participant do not exceed 3,270.

The safeguards against possible frauds in the finger-reading studies are summarized in the Appendix. This summary also can serve as a checklist while conducting finger-reading studies.

Conclusion

This paper presents a modified finger-reading training paradigm under stringent conditions. The author proposes this standard paradigm in the hope of attracting more researchers and resources to use its safeguards and investigate the finger-reading effect. However, these finger-reading training procedures might still have limitations even under perfect safeguards. Three sources affecting ESP performance cannot be entirely eliminated. The first is the psi ability of the participants or the experimenters. Psi is a general term including both ESP and psychokinesis (PK), an ability to achieve movement by mind alone (Irwin, 2004). Participants and/or experimenters might influence each other by using their psi abilities. Given the unknown nature of psi, concerns regarding the aspect of psi influence do not appear to be of immediate importance. The second source that could affect participants' ESP performance is the experimenter's attitude of believing in psi or not (Smith, 2003; Watt & Ramakers, 2003). However, the details of how this could happen are still unknown. One possible strategy that allows this possibility to be monitored is that the experimenter's and coexperimenter's beliefs in psi should be measured. These data might later be used to develop possible explanations of the finger-reading effect. The final possibility remains of experimenters or coexperimenters cheating, whether deliberately or unconsciously. Experimenters or coexperimenters could cheat in a variety of ways, such as making detectable marks on the targets, allowing or helping participants to cheat, or even changing the records. Possibly the best way to rule out potential fraud is via replication studies by different researchers (Alcock, 2003). This is another major reason for additional finger-reading studies to be undertaken, with a more universally agreed-upon methodological approach.

The finger-reading procedures were developed from Chinese culture. One might ask whether it can be found in Western culture. Needless to say, no studies about this issue have yet been undertaken. To answer this question, the author would like to make the initial assumption that if there is such a thing as ESP, it would be a universal possibility and not culture-specific. The author is now attempting to replicate the finger-reading effect in Edinburgh. It is considered a positive effort toward cooperation for the mutual benefit of both Western and Eastern research.

Finally, although this finger-reading training paradigm has been proposed, it may have to be modified in the future due to undiscovered possibilities of fraud or newly developed machines for detecting cheating. Although such changes might be inevitable, the proposed model will still be advantageous for finger-reading studies in the long run.

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APPENDIX

Possible frauds	Suggested safeguards
Peeking	1. Black bag 2. Barrier 3. A video camera should record the whole process and the recorded data should be examined by a different researcher to check for any peeking. 4. Experimenters and coexperimenters should make sure the cuffs of the barrier and bag are snugly tied/fitted around the forearms. 5. At least one experimenter and one coexperimenter should closely monitor the participant, with one positioned on each side of the barrier. 6. Sections of a participant's arm should be exposed between the cuffs (see Figure 2b.). 7. Participants should be told that moving the arms and pulling at the bags or cuffs are not allowed during the touching process. 8. The trial is invalid when a participant takes the stimulus out of the black bag or pulls at the tight cuffs of the barrier or bag, possibly causing openings. 9. Participants should not see any targets or their containers (small envelopes) until receiving feedback. 10. The samples should be placed in a sealed opaque envelope to ensure that the experimenter/coexperimenter and participants cannot see them and the envelope should not be opened until it has been inserted into the double-zipped bag. 11. If participants want to have a break during the experiment, the coexperimenter should seal the plastic opaque bag containing samples and put it in another locked room. 12. The experimental room should be isolated and should contain no windows, mirrors, or holes.
Experimenters – knowledge of targets	1. Experimenters and coexperimenters should not know the contents of the target envelopes until after each trial. 2. Targets should be prepared by another researcher who will not take part in the experiment.
Randomisation	1. A target should be randomly selected as a replacement from target pools and the procedure should be specified.

Recording	1. Both experimenters and coexperimenters should keep written records of participants' responses. 2. All participants' responses should be recorded by a video recorder in case the need for checking any details arises.
Replacement	1. Before the experiment, participants should be asked to show that their hands are empty, and especially not carrying any samples used in the experiment. 2. The coexperimenter should always check to be sure that the black bag is empty between trials. 3. After the experiment, the recorded data should be checked against the original data kept by the research assistant who prepared the samples.
Possible tactile cues or other cues	1. The production of samples should be in a standard way to minimise any tactile cues from the targets. 2. The stimuli, small envelopes, plastic bags, and big envelopes should be used only once. 3. If necessary, the samples can be checked later by another independent researcher to see if any obvious patterns were made by the person who prepared the targets. 4. Samples should not be used if a trial has been interrupted. 5. The person who prepares the targets should not have any relationship or contact with the participants or coexperimenters and should not take part in the experiment or be further involved with it in any way beyond the initial preparation of targets. 6. Only the research assistant who prepares the samples should be able to access the detailed information about the list of the stimuli. The information of the stimuli should be revealed only after the experiment has been conducted. 7. The participants should not be allowed to carry any mobile phones or radio equipment to guard against communication with any possible accomplice.

Appendix 3: The instructions given to the participants (Experiments 2, and 3)

1.Relax!

2.Take your time! Do not be in a hurry to finish.

3.You can keep your eyes open or closed.

4.Show me your hands (before experiment).

5.Explain to the participant the meaning of randomisation. For example, a number or an English word with a colour will be randomly selected as a replacement; thus, the same targets will possibly be repeated. There are no patterns here that participants could possibly predict.

6.Show participants how to tear the envelope to take the target paper out, since the target paper will be in middle of the envelope.

7.Show participants a fold in the top left corner as a cue for touching.

8.Free to use whatever scanning pressure and speed you choose.

9.Focus on touch and to imagine that you can see the numbers while touching the target.

10.Do not try to obtain imagery, just relax and let it come to you.

11.Say out loud everything you experience, as it occurs.

12.Do not take your hands out of the black bag during the touching procedure

13.Do not pull at the bags or cuffs and do not do any unnecessary movement of their arms. You can only take their hands out of the black bag after they tell the co-experimenter their final response.

14.Rate your images of targets, including, digits, words and their colours, if you experience mentation. Use a 1-7 scale where: 1= Not clear at all 7= As clear as normal vision (Only in the Experiment 3).

15.Your participation in this research is entirely voluntary. You are free to decline to be in this study, or to withdraw at any time for any reason, and you may decline to answer any questions with impunity.

Appendix 4: The letter for the principle of Hemei primary school (Experiment 1)

Dear Principle Lee

I am writing on behalf of one of my PhD students, Mr Yun-Chung Hsia. Mr Hsia is conducting a series of studies on children's tactile acuity. He is seeking your permission to have some of the children from Hemei primary school take part in his experimental study. The study involves children trying to identify letters embossed on a sheet of paper by touching the surface of the paper with their fingers, without looking at the sheet. The age range of participants is 7-13, and the study will take place during the early part of the summer holidays. This study has been approved by the psychology department's Ethics Committee, and the experimenters have appropriate Disclosure Scotland clearances. In addition, detailed informed parental consent forms would be sent to parents/carers as a precondition of taking part (one copy enclosed).

Mr Hsia seeks permission to put up a notice describing the experiment (copy enclosed) in the school, and possibly to give copies of the notice to teachers of classes in the appropriate age groups to send home with interested children to discuss with their parents. Children would be rewarded a gift for a contribution of their time for the study. Places are limited to just 24 children.

If you have any questions, please do not hesitate to contact me. My telephone number is +44-(0)-131-6511761 and e-mail address is hod.psych@ed.ac.uk.

Yours sincerely
Dr. Andy McKinlay,

Head of Psychology
School of Philosophy, Psychology and Language Sciences
The University of Edinburgh
7 George Square
Edinburgh EH8 9JZ, UK

Appendix 5: The notice of the tactile relief recognition (Experiment 1)

***TACTILE RELIEF RECOGNITION ***

WE REQUIRE VOLUNTEERS, AGES 7-13
TO TAKE PART IN
TARGETS THROUGH THE MEDIUM OF TOUCH

THE EXPERIMENTS WILL BE CONDUCTED IN THE HEMEI PRIMARY SCHOOL (after school and weekend times available)

For more information, and to apply for the necessary informed parental consent form, e-mail Daniel Hsia at s0239482@sms.ed.ac.uk or telephone on 0919709250.

Risks & Benefits: there are no known risks involved in participating in this type of experiment. The experiment has been approved by the University Ethics Committee as suitable for children. The primary benefit of participating in this study is that it will contribute valuable new data to advance our understanding of the limits of tactile recognition. You will be rewarded a gift after experiment.

Freedom to Withdraw: Your participation in this research is entirely voluntary. You are free to decline to be in this study, or to withdraw at any time for any reason, and you may decline to answer any questions with impunity.

Location: Hemei primary school

Appendix 6: Experiment information and consent form (Experiment 1)

Purpose of experiment: You are invited to participate in a study exploring the "tactile acuity".

Procedure: Before beginning the task, you will be interviewed with a questionnaire and the size of your index finger will be measured. You will be asked to identify letters embossed on a sheet of paper. In this task, you will try 324 samples. The sample will be a 2.3cm × 3cm rectangular piece of white paper. Embossed on the paper will be a one-digit number in the middle of the paper. The number 6 will be excluded. There will be 9 numbers in total.

During this task, you will be required to focus on touching and to see if you can feel or see the number on the paper. You will be allowed as many scans as you wish and using whatever scanning force and velocity you choose. You will need to inform the experimenter about whatever you see and feel. Finally, you will need to give the experimenter your final response. If you feel something on the paper, you will need to point out which number you have selected. If you can see or feel the exact number, you will be asked to tell the experimenter as well. No feedback will be given from the experimenter for this task. The whole task will take you about three hours to complete.

Data collected in this study: The data collected in this study is for use in my Ph.D thesis. Summary data may be used for presentations and discussions, or published in reports, but your name will not appear in any presentation of the data. This consent form, containing your full name, will be stored separately from the data in a secure room. Only the experimenter will have access to data which identifies you.

Risks and benefits: There are no known risks involved in participating in this type of experiment. The primary benefit of participating in this study is that it will contribute valuable data to advance our understanding of the nature of touch. You will be rewarded a gift to complete this task.

Freedom to withdraw: Your participation in this research is entirely voluntary. You are free to decline to be in this study, or to withdraw at any time for any reason, and you may decline to answer any questions with impunity.

Freedom to ask questions: If you have any questions, please ask the experimenter at any time. You can contact the experimenter in future if you have any further queries.

Researcher: Yun-Chung Hsia (Ph. D student in the Psychology Department of Edinburgh University)
Tel: 0919709272
E-mail: s0239482@sms.ed.ac.uk

Your signature indicates you understand that
1.The experiment is voluntary, and that
2.You may withdraw from the experiment at any time.

Please print your name________________________Your age__________
Your signature:__________________Your parent's signature:___________________

Appendix 7: The personal information questionnaire (Experiment 1)

PARTICIPANT QUESTIONNAIRE

1.Name:________________

2.Address:____

3.Phone:(work)____________________(home)__________________

4.Sex: ☐ Male ☐ Female

5.Age:_________

6.Educational background and/or vocational training:________________

7.If you touch something that you cannot see, such as in a darkened room, do you get a visual image of it?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not at all Very often

7.1 If yes, how clear is it?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not clear at all As clear as using normal vision

8. How good do you think your touch sensitivity is?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not very well Very well

9.On average how many hours do you currently use a keyboard (computer or typewriter) per day?___________

Please use the following instructions for answering the next 7 questions.

Please indicate your preferences for the use of your hands in the following activities by *putting + in the appropriate column.* Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, *use ++.* If in any case you are really indifferent *put + in both columns.*

Please try to answer all the questions, and only leave a blank if you have no experience at all of the object or task.

		Left hand	Right hand
1	Writing		
2	Drawing		
3	Throwing		
4	Scissor		
5	Toothbrush		
6	Knife (without fork)		
7	Spoon		

Appendix 8: The letter for the Headteacher of Sciennes primary school (Experiment 2)

Dear Ms Grierson

I am writing on behalf of one of my PhD students, Mr Yun-Chung Hsia. Mr Hsia is conducting a series of studies on children's tactile acuity. He is seeking your permission to have some of the children from Sciennes Primary School take part in his experimental study. He has already taken part in a similar study with children in Taiwan. The study involves children trying to identify letters printed on a sheet of paper by touching the surface of the paper with their fingers, without looking at the sheet. The age range of participants is 7-13, and the study will take place during the early part of the summer holidays. This study has been approved by the psychology department's Ethics Committee, and the experimenters have appropriate Disclosure Scotland clearances. In addition, detailed informed parental consent forms would be sent to parents/carers as a precondition of taking part (one copy enclosed).

Mr Hsia seeks permission to put up a notice describing the experiment (copy enclosed) in the school, and possibly to give copies of the notice to teachers of classes in the appropriate age groups to send home with interested children to discuss with their parents. Children would be paid £10 for a contribution of approximately eight hours of their time for the study. Places are limited to just 30 children.

If you have any questions, please do not hesitate to contact me. My telephone number is 651 1761 and e-mail address is hod.psych@ed.ac.uk.

Yours sincerely
Dr. Andy McKinlay,

Head of Psychology
School of Philosophy, Psychology and Language Sciences
The University of Edinburgh
7 George Square
Edinburgh EH8 9JZ
Telephone: 131- 651 1761
Fax: 131- 650 3440

Appendix 9: The notice of the finger-reading/tactile acuity study (Experiment 2)

FINGER-READING/TACTILE ACUITY STUDY

THE PSYCHOLOGY DEPARTMENT AT THE UNIVERSITY OF EDINBURGH

WE REQUIRE VOLUNTEERS, AGES 7-13

THE STUDY CONDUCTED ON CHILDREN'S ABILITIES TO RECOGNISE HIDDEN TARGETS THROUGH THE MEDIUM OF TOUCH

THE EXPERIMENTS WILL BE CONDUCTED IN THE PSYCHOLOGY DEPARTMENT AT THE UNIVERSITY OF EDINBURGH (after school and weekend times available)

For more information, and to apply for the necessary informed parental consent form, e-mail Wendy Martin at paradox65@hotmail.co.uk**, or telephone on 0131-466 8603**

Risks & Benefits: there are no known risks involved in participating in this type of experiment. The experiment has been approved by the University Ethics Committee as suitable for children, and the experimenters have the necessary Disclosure (Scotland) certificates. The primary benefit of participating in this study is that it will contribute valuable new data to advance our understanding of the nature of touch, and possibly even extrasensory perception. You will be paid £2.50 for each two hour visit you make.

Freedom to Withdraw: Your participation in this research is entirely voluntary. You are free to decline to be in this study, or to withdraw at any time for any reason, and you may decline to answer any questions with impunity.

Location: The Department of Psychology is located at 7 George Square Edinburgh EH8 9JZ.

Appendix 10: Experiment information and consent form (Experiment 2)

Purpose of experiment: You are invited to participate in a study exploring the "finger-reading/tactile acuity".

Procedure: Before beginning the task, you will be interviewed with a questionnaire. You will be asked to complete a printed text discrimination task.

You will try 80 samples, more if time allows. The sample will be a 5cm × 8 cm rectangular piece of white paper. Printed on the paper will be a two-digit number in the middle of the paper. However, the numbers 19 and 61, 18 and 81, 19 and 61, 66 and 99, 69 and 96, 68 and 89, 86 and 98, will be excluded.

During this task, you will be asked to focus on touching and to see if you can feel or see the number on the paper. You will be allowed as many scans as you wish and using whatever scanning force and velocity you choose. You will be asked to tell the experimenter whatever you see and feel. Finally, you will be required to give the experimenter your final responses. If you feel something on the paper, you will need to point out which number it is. If you can see or feel the exact number, you will also be asked to identify this.

Data collected in this study: The data collected in this study is for use in my Ph.D thesis. Summary data may be used for presentations and discussions, or published in reports, but your name will not appear in any presentation of the data. This consent form, containing your full name, will be stored separately from the data in a secure room. Only the experimenter will have access to data which identifies you.

Risks and benefits: There are no known risks involved in participating in this type of experiment. The primary benefit of participating in this study is that it will contribute valuable data to advance our understanding of the nature of touch. You will be paid ten pounds to complete this task.

Freedom to withdraw: Your participation in this research is entirely voluntary. You are free to decline to be in this study, or to withdraw at any time for any reason, and you may decline to answer any questions with impunity.

Freedom to ask questions: If you have any questions, please ask the experimenter at any time. You can contact the experimenter in future if you have any further queries.

Researcher: Yun-Chung Hsia (Ph. D student in the Psychology Department of Edinburgh University)
Tel: 131-650 3391
Fax: 131- 650 3369
E-mail: Daniel@moebius.psy.ed.ac.uk
Research assistant: Wendy Martin
Tel: 131-4668603
E-mail: paradox65@hotmail.co.uk

Your signature indicates you understand that
1.The experiment is voluntary, and that
2.You may withdraw from the experiment at any time.

Please print your name________________________Your age__________
Your signature:__________________Your parent's signature:___________________

Appendix 11: The personal information questionnaire (Experiment 2)

PARTICIPANT QUESTIONNAIRE

1.Name:__________________

2.Address:____

3.Phone:(work)______________________(home)__________________________

4.Sex: ☐ Male ☐ Female

5.Age:__________

6.Educational background and/or vocational training:_________________________

7.On average how many hours do you currently use a keyboard (computer or typewriter) per day?_____________

8.How easy is it for you to create a mental image of a familiar scene?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Impossible Effortless

9.If you can create a mental image of a familiar scene, how clearly can you see the scene?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not clear at all As clear as using normal vision

10. How well can you hear a sound in a mentally imaged scene?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not at all Very well

11. How well can you imagine smelling something?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not at all Very well

12. How easily can you experience a taste in a mentally imagined scene?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not at all Very easily

13. How well can you imagine feeling something through touching?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not at all Very well

14. If you touch something that you cannot see, such as in a darkened room, do you get a visual image of it?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not at all Very often

15. How good do you think your touch sensitivity is?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not very well Very well

16. Is the existence of ESP (extrasensory perception: reception of information without the use of known senses or logical inference)?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Certain Uncertain Impossible

17. Have you ever had an experience which is best explained by telepathy (ESP of the thoughts, feelings or behaviour of another person or organism)?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Yes Uncertain No

18. Have you ever had an experience which is best explained by clairvoyance (ESP of distant physical events or concealed objects)?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Yes Uncertain No

19. Have you ever had an experience which is best explained by precognition (ESP of future)?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Yes Uncertain No

20. Is the existence of PK (psychokinesis: mental influence on the physical world)?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Certain Uncertain Impossible

Please use the following instructions for answering the next 7 questions.

Please indicate your preferences for the use of your hands in the following activities by *putting + in the appropriate column.* Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, *use ++.* If in any case you are really indifferent *put + in both columns.*

Please try to answer all the questions, and only leave a blank if you have no experience at all of the object or task.

		Left hand	Right hand
1	Writing		
2	Drawing		
3	Throwing		
4	Scissor		
5	Toothbrush		
6	Knife (without fork)		
7	Spoon		

Appendix 12: The experimenter questionnaire (Experiment 2)

EXPERIMENTER QUESTIONNAIRE

1.Name:__________________

2.Address:____

3.Phone:(work)______________________(home)____________________________

4.Sex: ☐ Male ☐ Female

5.Age:__________

6.Educational background and/or vocational training:__________________________

7.Is the existence of ESP (extrasensory perception: reception of information without the use of known senses or logical inference)?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Certain Uncertain Impossible

8.Have you ever had an experience which is best explained by telepathy (ESP of the thoughts, feelings or behaviour of another person or organism)?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Yes Uncertain No

10. Have you ever had an experience which is best explained by clairvoyance (ESP of distant physical events or concealed objects)?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Yes Uncertain No

11. Have you ever had an experience which is best explained by precognition (ESP of future)?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Yes Uncertain No

12.Is the existence of PK (psychokinesis: mental influence on the physical world)?

☐ ☐ ☐ ☐ ☐ ☐ ☐

Certain Uncertain Impossible

Appendix 13: The letter for the principle of Hemei primary school (Experiment 3)

Dear Principle Lee

I am writing on behalf of one of my PhD students, Mr Yun-Chung Hsia. Mr Hsia is conducting a series of studies on children's tactile acuity/finger-reading ability. He is seeking your permission to have some of the children from Hemei Primary School take part in his experimental study. He has already taken part in a similar study with children in Taiwan. The study involves children trying to identify letters printed on a sheet of paper by touching the surface of the paper with their fingers, without looking at the sheet. The age range of participants is 7-13, and the study will take place during the early part of the summer holidays. This study has been approved by the psychology department's Ethics Committee, and the experimenters have appropriate Disclosure Scotland clearances. In addition, detailed informed parental consent forms would be sent to parents/carers as a precondition of taking part (one copy enclosed).

Mr Hsia seeks permission to put up a notice describing the experiment (copy enclosed) in the school, and possibly to give copies of the notice to teachers of classes in the appropriate age groups to send home with interested children to discuss with their parents. Children would be rewarded a gift for a contribution of their time for the study.

If you have any questions, please do not hesitate to contact me. My telephone number is +44-(0)-131-6511761 and e-mail address is hod.psych@ed.ac.uk.

Yours sincerely
Dr. Andy McKinlay,

Head of Psychology
School of Philosophy, Psychology and Language Sciences
The University of Edinburgh
7 George Square
Edinburgh EH8 9JZ
Telephone: +44- (0)131-6511761
Fax: +44 -(0)131-6503440

Appendix 14: The notice of the tactile acuity/finger-reading study (Experiment 3)

TACTILE ACUITY/FINGER-READING STUDY

WE REQUIRE VOLUNTEERS, AGES 7-13
TO TAKE PART IN
THE STUDY CONDUCTED ON
CHILDREN'S ABILITIES TO RECOGNISE HIDDEN TARGETS THROUGH THE MEDIUM OF TOUCH

THE EXPERIMENTS WILL BE CONDUCTED IN THE HEMEI PRIMARY SCHOOL (after school and weekend times available)

For more information, and to apply for the necessary informed parental consent form, e-mail Daniel Hsia at s0239482@sms.ed.ac. **or telephone on 0919709250**

Risks & Benefits: there are no known risks involved in participating in this type of experiment. The experiment has been approved by the University Ethics Committee as suitable for children, and the experimenters have the necessary Disclosure (Scotland) certificates. The primary benefit of participating in this study is that it will contribute valuable new data to advance our understanding of the nature of touch, and possibly even extrasensory perception. You will be rewarded a gift for a contribution of your time.

Freedom to Withdraw: Your participation in this research is entirely voluntary. You are free to decline to be in this study, or to withdraw at any time for any reason, and you may decline to answer any questions with impunity.

Location: Hemei primary school

Appendix 15: Experiment information and consent form (Experiment 3)

Purpose of experiment: You are invited to participate in a study exploring the "tactile acuity/finger reading".

Procedure: Before beginning the task, you will be interviewed with a questionnaire. You will complete 10 trials in the selection study. If you have a significant result in the selection study, you will be invited to the confirmation study for 20 trials. If you have a significant result in the confirmation study, you will be invited to the training study for 80 trials in the. The sample will be a 5cm × 8 cm rectangular piece of white paper. Printed on the paper will be a two-digit number in the middle of the paper. However, the numbers 19 and 61, 18 and 81, 19 and 61, 66 and 99, 69 and 96, 68 and 89, 86 and 98, will be excluded.

During this task, you will be asked to focus on touching and to see if you can feel or see the number on the paper. You will be allowed as many scans as you wish and using whatever scanning force and velocity you choose. You will be asked to tell the experimenter whatever you see and feel. Finally, you will be required to give the experimenter your final responses. If you feel something on the paper, you will need to point out which number it is. If you can see or feel the exact number, you will also be asked to identify this.

Data collected in this study: The data collected in this study is for use in my Ph.D thesis. Summary data may be used for presentations and discussions, or published in reports, but your name will not appear in any presentation of the data. This consent form, containing your full name, will be stored separately from the data in a secure room. Only the experimenter will have access to data which identifies you.

Risks and benefits: There are no known risks involved in participating in this type of experiment. The primary benefit of participating in this study is that it will contribute valuable data to advance our understanding of the nature of touch. You will be rewarded a gift to complete this task.

Freedom to withdraw: Your participation in this research is entirely voluntary. You are free to decline to be in this study, or to withdraw at any time for any reason, and you may decline to answer any questions with impunity.

Freedom to ask questions: If you have any questions, please ask the experimenter at any time. You can contact the experimenter in future if you have any further queries.

Researcher: Yun-Chung Hsia (Ph. D student in the Psychology Department of Edinburgh University)
Tel: 0919709272
E-mail: s0239482@sms.ed.ac.uk

Your signature indicates you understand that
1.The experiment is voluntary, and that
2.You may withdraw from the experiment at any time.

Please print your name________________________Your age__________
Your signature:__________________Your parent's signature:___________________

Appendix 16: The imagery categories (Experiment 3)

Type of image:

1.☐Open eyes or ☐Closed eyes

2.☐Transparent or ☐Opaque image

3.☐Developed from an undeveloped image

4.☐Result of a transformation

5.☐Bizarre

6.☐Personal memory or experience

7.☐As same as the targets

8.☐Auditory

Duration:

9. ☐Fleeting

10.☐Persistent: an image which stays in the mind awhile; how long:__________

11.☐Recurrent; how many times?______________

Clarity:

12.Participants subjectively rate images of targets (digits, and their colours)

12-1 First digit

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not clear at all — As clear as using normal vision

12-2 Second digit

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not clear at all | As clear as using normal vision

12-3 Colour

☐ ☐ ☐ ☐ ☐ ☐ ☐

Not clear at all | As clear as using normal vision